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MECHANICAL ENGINEERING
May 1936

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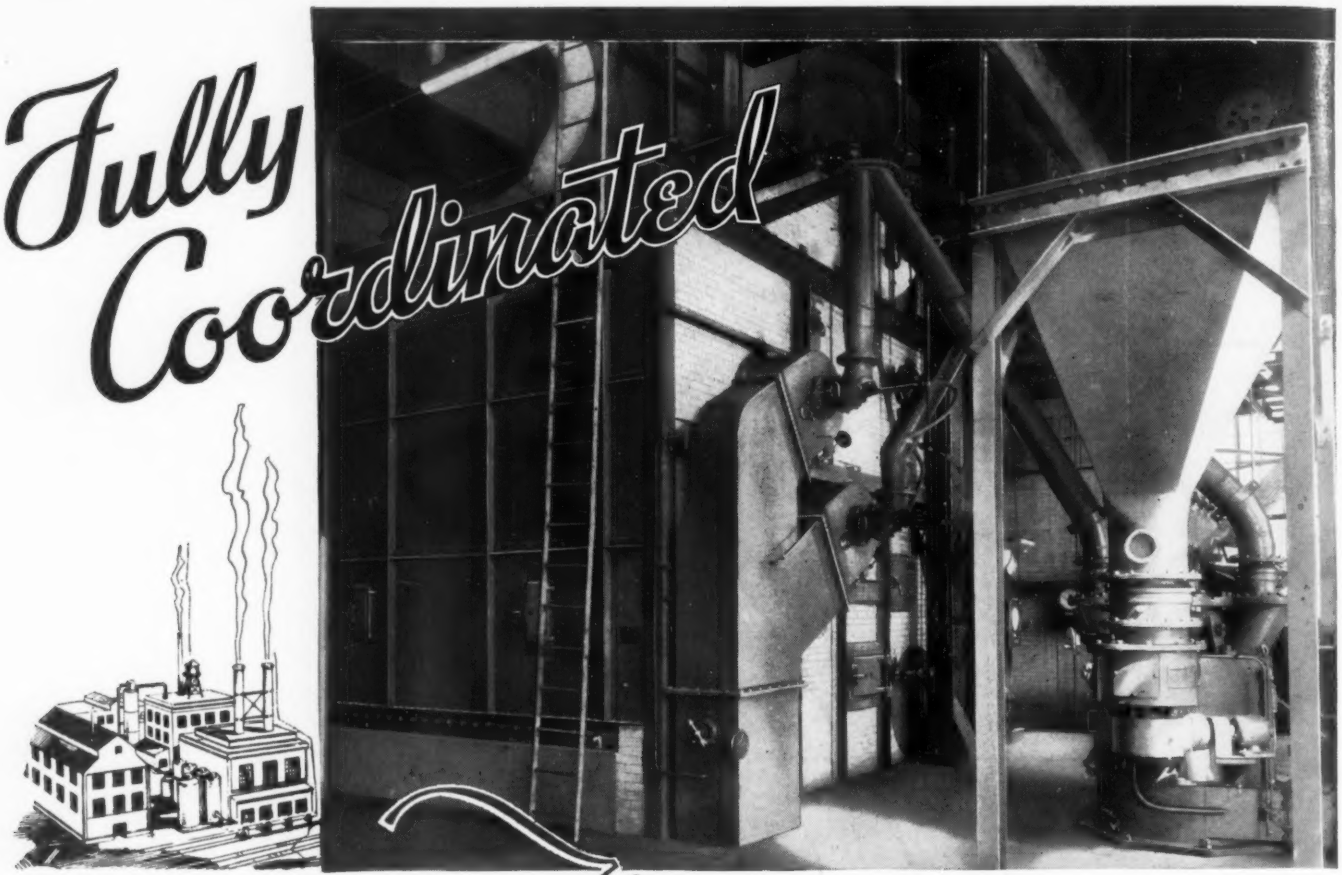

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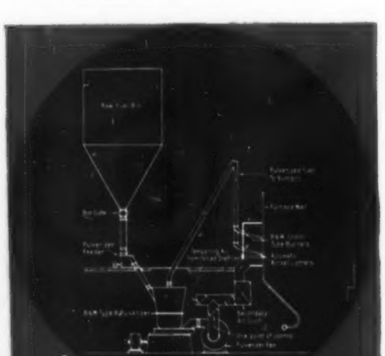

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Main Street, Dallas, Texas

The 1936 Semi-Annual Meeting of The American Society of Mechanical Engineers will be held in Dallas, June 15–20. For further details see pages 332 to 336 of this issue.

Volume 58
No. 5

MECHANICAL ENGINEERING

May
1936

GEORGE A. STETSON, *Editor*

To Dallas in June

BECAUSE of the inevitable relationships which mechanical engineers bear to industry, a bulk of the membership of The American Society of Mechanical Engineers is to be found in the industrial northeastern section of the country. Outside of this area, however, are other centers of engineering activity, many of which have national, as well as local, significance and influence.

Every section of the country has provided opportunity for mechanical engineers to exercise their talents on problems peculiar to that locality. Certain places boast examples of engineering practice that are so unique that they can be seen nowhere else. Opportunity to see and learn about these specialties is eagerly sought and hugely appreciated by the ever-inquiring alert engineer. And the stimulus to the members of the profession who find themselves in the rôle of hosts has an uplifting effect upon their own commendable pride in their work.

Dallas, Texas, center of a region of growing opportunity for the engineer, is to be the scene of the 1936 Semi-Annual Meeting of The American Society of Mechanical Engineers. Scheduled for June 15 to 20, the meeting will afford engineers from other parts of the country a profitable holiday. On pages 332 to 336 of this issue plans and program are presented in detail.

Noise Abatement Sorely Needed

FROM time to time attention is directed to noise abatement—a particularly appropriate field in which the engineer may develop his talents for the good of all.

Most of the noises with which modern civilization is cursed have their origin in the works of engineers. Some of them, alas, seem to be almost inevitable, while others become a nuisance because of the abuse of machinery in the hands of careless and thoughtless persons. But wherever the fault lies, engineers will earn the undying gratitude of the world, and remove the basis for much complaint of their profession, if they put their minds to the solution of the problem of noise.

Fortunately, engineers understand the conditions in design and operation that must be met. They have instruments for measuring noise intensity and for locating the sources of noise. Their ingenuity in design is sufficient to guarantee an intelligent attack on elimination and abatement. What is lacking is a desire to make the effort and a conviction that it is worthwhile.

One place to begin is at the source—in design. The Detroit Edison Company, to cite an example of purposeful action, has introduced noise specifications into its general specifications for gear cases. This has forced designers and builders of equipment to pay more than usual attention to this factor in design and construction. It is a step in the right direction, and perhaps a forerunner of the day when a consideration of noise will be part of the routine of design, just as effective lubrication, safety features, control devices, and a host of other refinements have become. We may even look forward to the time when no textbook on design will be complete without a section devoted to this important subject. For unless we start with a machine that is as quiet as man can make it, we cannot expect to make much progress in silencing a world too filled with the noise of man's progress. Here is an engineering problem worthy of study and solution.

Aeronautics in the News

THE march of events affords another opportunity to remind engineers of the progress in aeronautics that is being made by the airship. During recent weeks the *von Hindenburg*, largest airship afloat, made its initial flight from Friederichshafen to South America and return. Public notices of the flight have been of more than technical interest; but chief of the dramatic events was the safe return, accomplished with rare skill by the navigators and operators of the ship, under conditions none too favorable. The loss of two motors caused universal concern and required a change in course, but no serious consequences resulted to spoil the enviable record held by commercial ships of this character. Concurrently, the tragic accidents to several heavier-than-air craft in regular transport service provided a striking contrast, much to be regretted by all friends and proponents of air travel.

It has been our privilege in recent issues to present papers on aeronautical subjects that must have convinced readers not familiar with this growing industry that remarkable progress is being made, particularly when it is realized that it has only been within the lifetime of most engineers practicing today that aerial flight has become more than a dream or a hazardous experiment. The regular services between remote parts of the earth and over vast oceans and lands where other forms of travel are slow and in some cases nonexistant, with arrivals and departures as regularly scheduled and accomplished as in much older forms of travel, stand as a tribute to

man's engineering skill and his pioneering courage. Progress in air travel will continue to provide opportunities for engineering services, not only in the work of devising new, better, and safer machines and facilities, but in operation and maintenance in all the departments into which a great transportation industry is organized.

That much is yet to be accomplished everybody will admit. In this country, as has been pointed out from time to time, the field of the airship particuarly needs close study and extensive experimentation. Prejudice against the airship, resulting from tragic experiences with its military use, should be offset by the perfect record of commercial flights, and by the confidence which the Germans have in their craft. Perfection in the design of the craft itself and in its propelling mechanism must be supplemented by trained operating personnel, familiar with and competent to cope with the conditions of aerial traffic in all kinds of weather. There is no reason why this country should not develop ships and men that will win universal confidence and serve usefully in long-distance transportation.

Producing Less to Share

FEW will disagree with the assertion that what the world most sorely needs is a solution to the problem of unemployment. In every civilized nation, side by side with questions of political, social, and economic survival, comparing in importance and perplexity with that of war and peace, unemployment exists to an extent that is an astounding contradiction to the volume of human needs and man's capacity for production of material things that modern science and technology have made available. A confusion of counsels exists. The principal solutions are contradictory.

This is no place to point out the true path or the one best way, even if it were known and could be demonstrated beyond a doubt. Confidence in the future, maldistribution of wealth and income, clashing and incompatible interests of well-recognized groups, the conflicting philosophies of capitalistic, collectivist, and fascist society, higher wages, shorter working hours, technological unemployment—whatever commends itself as paramount to one person as a way out is to another a way into deeper confusion and more inevitable ruin. Honest as we may try to be, we are confused.

Most engineers, from their own experiences, will admit that we cannot have more by producing less. They feel that if this one principle could be made to harmonize with hundreds of others, and be worked out in our national economy which too frequently, it seems, is directed along lines that are contradictory to it, we should be further advanced toward a solution of unemployment that most people would welcome. Knowing how machinery has increased the world's supply of material things, engineers resent suggestions to limit the use of machinery. Common sense tells them that there will be more to divide if more is produced and that increased production will result from the employment of more persons. Greater leisure may be a desirable social dividend, but it should be paid out of earnings, and not out of capital. So long as justifiable wants go unsatisfied, the earnings of society would seem to be inadequate.

All this sounds simple and sensible enough to have earmarks of the truth. And yet to apply the principle harmoniously to national life arouses conflicts of opinion and purpose. Other points of view must be examined critically and harmony attempted, but the engineer will be wise to urge a corresponding examination of what he believes and not lose sight of its obvious validity. Unemployment ceases when men have jobs with which to support themselves and not by finding new excuses for leisure or sharing a job with some one else. When we share the work of production, we share its fruits also. Under such conditions employment degrades the standard of living.

Worthwhile Papers by Practical Men

IN AN editorial in the January 24, 1936, issue of *The Engineer* attention is directed to an appeal printed in the *Journal* of the Institution of Mechanical Engineers which reads as follows: "The Council take this opportunity to urge members who are engaged in practical mechanical engineering to submit papers on technical subjects. They recognize that the design and operations of machinery of all kinds, the lay-out of workshops, workshop methods and appliances, and all such practical subjects as come within the daily experience of mechanical engineers, are of equal interest with scientific subjects."

Translating this plea into words that would make it apply to the mechanical engineering profession in this country, we would like to second the appeal as well as the able manner in which the editor of *The Engineer* presents his reasons for favoring it. For there is little doubt but what a great and important field of engineering literature is being neglected owing to the failure of engineers to discuss frankly and helpfully the practical problems with which a majority of engineers are faced.

That such material must exist can hardly be doubted when the extent of the field of mechanical engineering is contemplated. In March we presented the results of a study of the industries with which members of the A.S.M.E. are engaged. It was shown that more than 55 per cent of the members are to be found in manufacturing. Yet no such percentage of volume of subject matter is to be found in the Society's publications. The reason is not that such material is unwelcome; it seldom puts in an appearance. Yet if it were available, in brief, concisely written statements of problems that are general to many lines of production and manufacturing, a greater number of readers would find interest in the Society's publications without materially curtailing the volume of research and applied-science papers of chief interest to those working in these fields.

STRESSED-SKIN CONSTRUCTION

Influence of Aircraft Design on Other Types of Structures

By CARL F. GREENE

U. S. ARMY AIR CORPS, WRIGHT FIELD, DAYTON, OHIO

ONE OF the most useful and far-reaching contributions to everyday engineering construction is now being made or stimulated by certain modern developments in the structures of aircraft. This consists substantially in the transition from internal structural frameworks to external structural shells.

Inasmuch as the structural effectiveness of shells depends largely on the symmetry and smoothness of their exteriors, it is natural that such a transition should result in a great improvement in the external grace and appearance of the objects affected. The grace thus acquired has been fitted with the general term "streamlining," which is, of course, particularly appropriate only in the cases of objects required to pass readily through a fluid medium.

The earliest marked results of the streamlining influence became apparent a little over a year ago with the advent of the new automobiles, motor busses, and railroad trains. These, of course, were really streamlined to some extent, but this external smoothing out was in these as well as in other cases simply the outward manifestation and by-product of a major structural improvement.

This structural improvement, or the application of the "strength of form" conception to modern structural bodies, had for its original exemplification such things as eggshells and the casings of shell fish; the bamboo shaft and the hollow wheat straw. Later this principle of the strength of form found expression by man in masonry arches, and later still in such efficient structures as were used in the hulls of ships, submarines, tunnel linings, boilers, and steel smoke stacks. Thereafter, apparently, for a considerable period this type of construction was not extended to include many other applications. The external surface and the internal framework of a great number of structural and mechanical bodies remained through years of development, two distinct systems with two distinct functions. For many years no extension of the lesson of the eggshell and its modern expression, the submarine and the tunnel tube, appears to have been made. Apparently, the type of construction exemplified by the hulls of ships and of submarines did not impress itself on the designers and constructors of other structural systems as applicable to their own particular problems.

It did not occur to these constructors to question existing structural practices which took it for granted that in many forms of construction there had to be an external surface and an internal structure. When the airplane constructor began to build airplanes his first structural systems consisted of exposed frameworks of wood, fabric, and wire. Gradually, it was found desirable and possible to enclose some of these frameworks in stretched-fabric envelopes. Accordingly, the wing became a double-surfaced body enclosed by a fabric covering housing the necessary structure. The central framework of the body, carrying the engine on the front end and the tail surfaces on the rear, was covered with fabric, doped, stretched, and painted. For a long time this arrangement of wings and fuselage was universally used and appeared to have become fixed. However, the pressure of higher performance which demanded more substantial surfaces, greater structural efficiency, the elimination of external bracing, and maximum torsional rigidity resulted in the development of structural systems both for wings and fuselages that have inspired in other lines of fabrication a renewal of engineering interest in efficient new applications of old systems of construction. In other words the airplane structure has emerged from the dark interior of the airplane and has now become merged with the graceful, shining exterior which we now see on the modern airplane. This transition from awkward skeleton to graceful, efficient outer shell has been completed throughout most of the airplane.

In the making of this transition the aircraft constructor has been compelled to feel his way and prove his work as he went along. As the structure assumed more and more the character of a shell the problem of structural analysis became increasingly difficult. Eventually, a somewhat new technique of design and analysis made its appearance. This technique has for its basis and guiding principle an attempt at the analysis of the progressive structural contributions of the components of the system throughout the range of the loading, rather than the making of a definite strength evaluation against certain assigned design conditions.

It is apparent that structural assemblies such as the metal wings and fuselages of modern airplanes, made up of comparatively thin and easily buckled materials, undergo certain physical changes and redistributions of work during the application of increasingly great external loads. The structure, as it existed just prior to failure, becomes an entirely different system from the structure which absorbed the small loads applied at the beginning of the test. The reason for this lies in the fact that in any structural member under flexure the compression stresses developed in one surface are distributed and absorbed in an entirely different manner from the tension stresses developed in the opposite surface. Throughout the bending action, the material of the surface in tension tends to build up stress in a uniform manner, and none of the material becomes ineffective until the stress approaches the ultimate strength of the material. On the compression surface, however, the action is entirely different. In the case of major aircraft assemblies the surface or shell is usually made up of a thin external skin on the outside and a system of longitudinal stringers on the inside, as in Fig. 1.

Inasmuch as many of the features involved in a modern wing analysis exemplify to a large extent the basic changes in structural procedure brought about through the development of modern aircraft a brief example of a modern stressed-skin wing follows:

In this wing the application of the bending-stress formula

$$f = MC/I \qquad [1]$$

Contributed by the Aeronautic Division and the St. Louis Section, and presented at the National Aeronautic Meeting, St. Louis, Mo., Oct. 10–12, 1935, of The American Society of Mechanical Engineers.

in which

f = the unit compressive or tensile stress, lb per sq in.
M = bending moment, in-lb
I = moment of inertia of the cross-sectional area of the beam about its neutral axis, in.[4]
C = distance from the neutral axis of the fiber under consideration, in.

requires special consideration on account of the great differences in the stress supporting properties of the various material components.

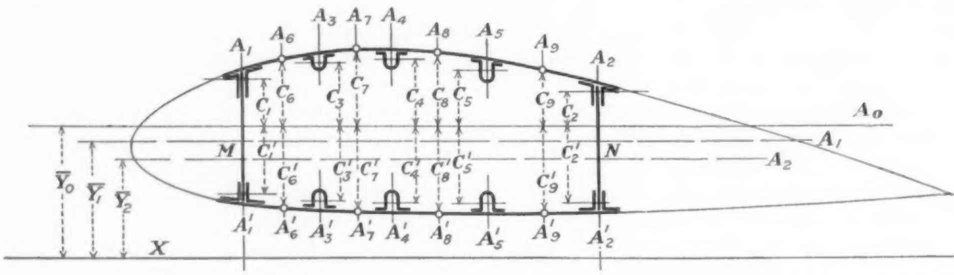

FIG. 1 SECTION OF STRESSED-SKIN WING WITH LONGITUDINAL STRINGERS

With reference to Fig. 1, we note that the essential elements of such a wing are

1 The webs M and N.
2 The flange stringers:
(*a*) Those attached to the webs A_1, A_2, A_1', and A_2'.
(*b*) The reinforcing stringers A_3, A_4, A_5, A_3', A_4', and A_5'.
3 The skin designated by increments, as A_6, A_7, A_8, A_9, A_6', A_7', A_8', and A_9'.

The stringers and the skin are designed to carry the bending loads, tension, and compression.

In determining the design stress, tension or compression, by Equation [1], the following limitations should be observed:

(*a*) The formula does not apply, with theoretical accuracy, above the proportional limit of the material.

(*b*) The instability of the structural parts; that is, the critical column stress of the stringers and the skin under edge compression.

In this type of structure, the stress limit of the stability of the structure is generally less than the stress at the proportional limit of the material. Thus if the critical instability stress is designated by P/A as in the case of columns, we have

$$f < P/A \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [2]$$

That is, the stress as calculated from Equation [1] must be less than the critical buckling P/A of the part under consideration.

Assuming that the upper flange of the wing, Fig. 1, is under compression, due to bending, we note three critical stresses:

1 The critical P/A stress of the skin, proportional to the ratio of the thickness of the skin to its radius of curvature.

2 The critical P/A stress of the stringers, A_3, A_4, and A_5.

3 The critical P/A stress of the stringers A_1 and A_2. Designating these stresses respectively by f_1, f_2, and f_3, let us assume that

$$f_1 < f_2 < f_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [3]$$

From zero stress to the fiber stress f_1, in the skin, the neutral axis is the centroid of the cross-sectional area of the skin and the stringers, that is

$$\bar{Y}_0 = \frac{A_1Y_1 + A_2Y_2 + \ldots. A_9Y_9 + A_1'Y_1' + \ldots A_9'Y_9'}{A_1 + A_2 + \ldots. A_9 + A_1' + \ldots\ldots A_9'} \ldots [4]$$

in which Y is the distance of the area from the reference line X.

The moment of inertia is the moment of inertia of all the area of Equation [4] about this centroidal axis A_0; that is

$$I_0 = AC^2 + A_1C_1^2 + \ldots A_9C_9 + A_1'(C_1')^2 + \ldots A_9'(C_9')^2 . [5]$$

In this case,

$$f_1 = M_1\, C_8/I_0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots [6]$$

since f_1 is a maximum when $C = C_9$. (See Fig. 1.)

The allowable bending moment, above which wrinkling of the skin first occurs, is, from Equation [6]

$$M_1 = f_1\, I_0/C_9 \ldots\ldots [7]$$

When the skin of the compression surface wrinkles, the P/A stress carried by it is very low, so that we are justified in assuming that it no longer acts, hence we may assume that it is removed. For higher stresses we must recalculate the location of the neutral axis and the moment of inertia of the cross section, omitting the area of the skin of the upper flange. The lower flange, being under tension, is not subject to instability, hence, the skin of that flange continues to carry its portion of the load.

Assume that the recalculated value of $\bar{Y}$, using Equation [4] but omitting A_6, A_7, A_8, and A_9, is $\bar{Y}_1$ (see Fig. 1); and that the recalculated value of I is I_1. The value of C is now measured from A_1.

Since A_4 is the greatest distance from the neutral axis, it will be the first to buckle, assuming that the stringers are similar

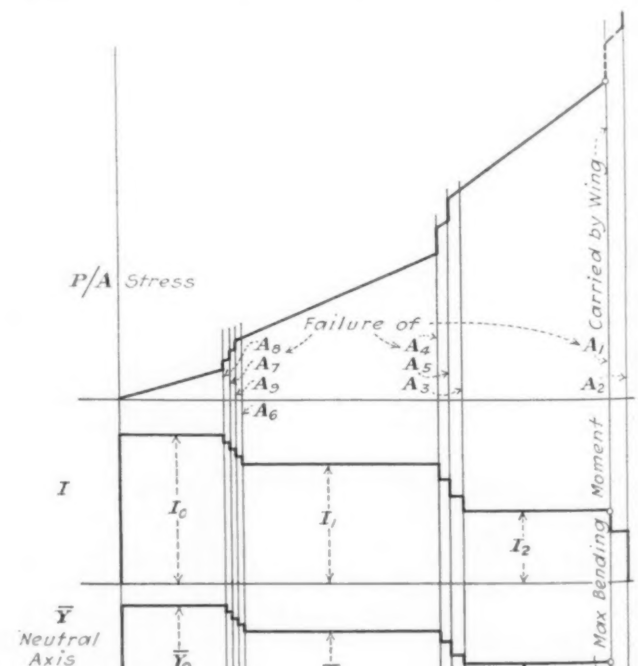

FIG. 2 DIAGRAM OF PROGRESSIVE FAILURE OF WING OF FIG. 1

and are equal in area. Let the buckling stress be f_2, hence

$$f_2 = M_2\,C_4/I_2 \qquad [8]$$

$$M_2 = f_2 I_2/C_1 \qquad [9]$$

Assuming successive failures of stringers A_3, A_4, and A_5, recalculating $\bar{Y}$ and I, under the assumption that the stringers have been removed, and designating these as $\bar{Y}_2$ and I_3, we find

$$M_3 = f_3 I_3/C_{(1 \text{ or } 2)} \qquad [10]$$

Under the assumption that $M_1 < M_2 < M_3$, we may represent the movement of the neutral axis $\bar{Y}$, and the variation of the moment of inertia and the stress as a function of the bending moment by a diagram similar to that of Fig. 2. We may justifiably call this a diagram of "progressive failure."

Apparently an ideal structure would be one in which the members reach their critical stress at the same bending moment so as to preclude progressive failure. It is difficult, however, to bring the critical stress of the skin (by reinforcing) up to a high enough value for reasonable efficiency. In general, therefore, M_2, the bending moment carried by all the stringers, is the maximum design bending moment.

This means that at a low bending moment the skin of the wing will wrinkle. To avoid this wrinkling it would be necessary to relieve the skin of its load-carrying ability by the use of sliding joints; or by introducing a high initial tensile stress in the skin. Since the skin supplies the torsional rigidity of the wing, the sliding joint is not practicable. The prestressed skin construction has not been resorted to because of the difficulties of construction.

It is apparent that in structures such as the one just considered the ultimate strength is almost wholly dependent on the last material (in this case A_1 and A_2) to be on its feet, so to speak, at final failure. The material which buckled and passed out

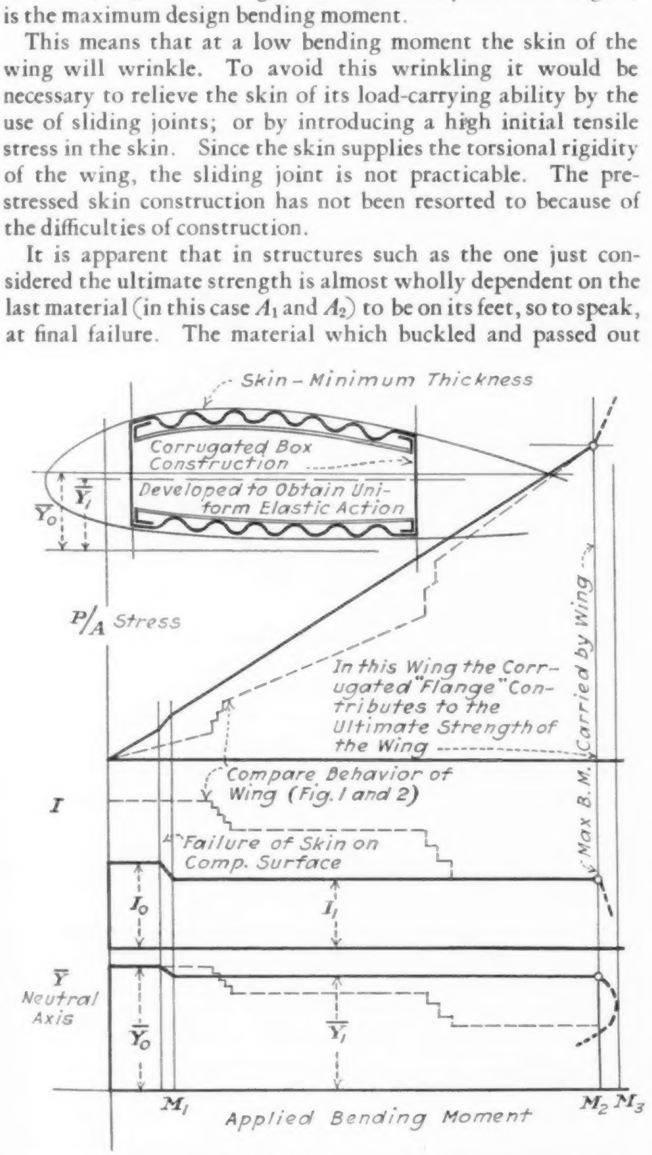

FIG. 3 WING OF FIG. 1 REDESIGNED TO AVOID PROGRESSIVE FAILURE

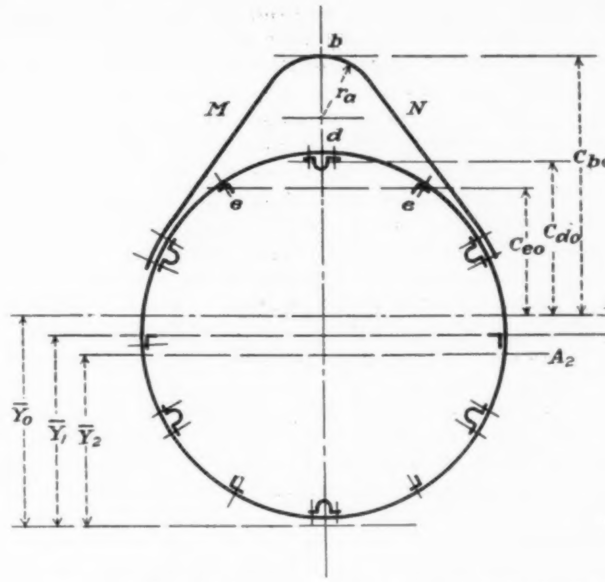

FIG. 4 EFFECT OF ADDING COCKPIT FAIRING TO FUSELAGE

of consideration earlier in the action, while contributing initially to the rigidity of the wing both in bending and torsion, did not have much effect on the ultimate strength of the wing. Consequently, in order to obtain the maximum of efficiency with a given weight of structural material, it is obvious that one of the most important characteristics to aim at is that of elastic homogeneity. In other words, so to proportion and distribute the material as to have as little of it as possible become ineffective prior to the general failure of the entire assembly, Fig. 3; a sort of "One Hoss Shay" of structural design, in which all parts of the unit are equally strong in proportion to the magnitude of the stresses developed in them.

To state, for example, that stringers A_3, A_4, A_5 (Fig. 1) are good for a certain stress in compression does not mean that these stringers will actually carry this stress up to and as a part of the final ultimate strength of the wing. On the contrary, although the maximum allowable stress may be developed in these portions fairly early in the loading, it is reasonably certain that when the ultimate strength of the structure has been reached, the resistances developed in these stringers will have fallen decidedly below their maximum capacities. Furthermore, even if the designer actually disregards mathematically the material which, through buckling or other distortion, has passed out of consideration early in the action, this material is still present and by its distortion is interfering with the stability and behavior of adjacent material. Thus the skin of a fuselage has been known by wrinkling to induce premature failure in the attached stringers. Similarly, the distortion of a group of light stringers can induce premature failure in transverse formers or in adjacent stringers of much higher capacity. Therefore, the designer of modern, close-knit shell structures seeks to avoid or minimize conditions such as these.

Ordinary structural practice governing bridge and building design does not give much consideration to such points. The column capacities of the various components of a compression system are solemnly computed and combined under the assumption that their values will hold good all the way to the ultimate strength of the structure as a whole. It is fortunate in many cases that such structures are designed with theoretical factors of safety in the neighborhood of 4, and that the theoretical yield points of the components are never reached in use, even under maximum load.

To return to the aircraft structure, it frequently happens during the making of a design that what started out to be a clear-cut monocoque fuselage or shell wing becomes tremendously complicated by the cutting of good sized holes or by the addition of secondary material of one sort or another. In the former case the material adjacent to the hole or discontinuity can be reinforced to restore the theoretical strength of the system—at a cost in added weight and, in spite of the figures, with an actual loss in effectiveness. In the latter case the addition of so-called "idle" material, such as cowling and flooring, brings up the well-known rule now heard so frequently in aircraft-design rooms, "Hold it or turn it loose." In other words, if material is rigidly connected to the structure it must be made to conform to the elastic or stress condition present in that region. The designer may say, "I don't count this material as structure," but if the material is rigidly connected to the structure it *does* take part in the elastic action of the structure, or else it should be freed, by flexible connections or otherwise, from being forced to follow the distortion of the main structure.

The foregoing is illustrated by the addition of cockpit streamlining to a fuselage, as shown in Fig. 4. As noted in the figure, we have the same type of shift of the neutral axis, and the same type of change of moment of inertia, upon the successive failures at b, d, and e under compression, as in the wing.

Due to the large value of C_{b0}, the distance from the neutral axis of the point b, in comparison with C_{d0}, the corresponding distance of d, the stress at b will build up much more rapidly with the bending moment than the stress at d. Hence, it may be expected that the fairing MN will wrinkle badly at a low load factor. It would be desirable, in this case, if the streamlining must be added, either actually to design the composite structure as a unit or to provide for a slight movement in the transverse joints of the sheet metal, so as to allow for the elastic deformation of the fuselage without building up a stress in this fairing. This latter is substantially what is accomplished in shipbuilding practice where expansion joints extending completely through the upper decks of large ships protect the comparatively lightly constructed superstructure from stresses imposed upon it by the flexural action of the hull.

The narrow margins of safety and the accelerated fatigue conditions to which aircraft structures are subjected have given emphasis to the fallaciousness of a number of engineering practices. For instance, in making repairs to a member usually no account is made of material added, although this very excess of material may actually produce a weakening effect. Abrupt changes of section and related evils, such as insufficiently filleted corners and notches, while recognized and evaluated by photoelastic methods years ago, have never been completely exposed and discredited until brought to trial by the recent severe demands of aircraft construction. Continuity and uniformity have been shown to be the highest of structural virtues, and, consequently, symmetry and grace have become the outward manifestations of inner effectiveness and economy.

In many branches of everyday construction there exists a marked disregard for elastic consistency. Although expansion joints and structural relief are provided in bridges, pipe lines, concrete paving slabs, and other large structural systems, there are many places where improper stress distribution, differentials of expansion, and poor follow-through place unfair work on portions of the structures or operate to lead the designer to establish rules which, in dealing with problems in applied design, provide an excess of structural material rather than a better distribution of less material.

The fact is that many of the construction handbooks, containing large amounts of easily applied data, while undeniably excellent and useful compendia of information, are, after all, published by the manufacturers of the various chief materials of construction and their general use could not be expected to operate in favor of greater material economy. Unfortunately for good design, materials in America are relatively cheap, while engineering labor is regarded as expensive, consequently the school of design based upon catalog data furnished by manufacturers tends to prevail in ordinary construction.

The development of efficient aircraft structures has pointed out the rewards to be derived from refinement of structural methods. This refinement has been made possible largely as a result of the tremendous advantage enjoyed by the aircraft constructor of being able to verify his computations in the static-test laboratory. Here he is able to observe the elastic behavior and progressive failures of full-sized structures and to supplement or modify his theoretical computations in the light of actual observation and direct experience. Unfortunately, the bridge and building constructor does not have this advantage and in general cannot be aware that portions of his structure are grossly overweight and overstrength, while other portions are unfairly loaded and possibly dangerously weak. In certain engineering fields aircraft experience has already made itself felt. The recent streamlined trains, automobiles, and busses represent essentially and primarily more progressive structures; the streamlining feature being secondary. In the automobile it is evident that the engineer cannot move faster than public taste or vogue will allow. Otherwise I am sure that the present collection of chassis, bodies, mudguards, lamps, bumpers, running boards, and other unrelated components and excrescences, directly descended from and bearing a strong family resemblance to the buggy, would long ago have been transformed by the engineers into a real vehicle, offering interior accommodation commensurate with the road space taken up, presenting a smooth, truly streamline exterior combining all structural components in one shell-type body, and, last but not least, introducing a weight per passenger ratio far below the average now considered satisfactory. Style and public reluctance to accept novel features, particularly those affecting appearance, make it necessary for automobile manufacturers to proceed cautiously in making changes. The whip sockets have been bravely removed but the buggy lamps and flaring mudguards remain. The foregoing applies with almost equal force to many products, but there are many others in which a considerable transformation is becoming apparent. Houses are changing in form and in methods of construction, household equipment and furniture are departing from time-honored forms and yielding to new methods of design; even such things as machinery show marked tendencies along the same lines—simplicity, grace, and efficiency. Our styles in clothes, for the time being at least, are conforming to that same trend. Bridges, even that hideous old hold-out, the steel through span—are beginning to show evidence of an increase in engineering effort.

It is not claimed, of course, that aircraft construction practice has been responsible for all of the changes now taking place in other fields of engineering, but it is a fact that the airplane furnishes us today the highest expression of the union of beauty of outline and operating economy—of structural simplicity and efficiency. It can therefore be reasonably stated that the example set by the aircraft constructor has at least established certain higher standards of design and construction—applicable to an extremely great variety of products—and has thereby definitely demonstrated the benefits to be derived from the real and continual engineering improvement of these products. Trends of design—with aircraft in the van—are definitely toward the sound and useful and away from the externally ornamented and internally inefficient.

An INDICATOR *for* HIGH-SPEED ENGINES

By H. T. SAWYER

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THE EXTREMELY high speed of the internal-combustion engine makes it difficult to design an indicator that will record accurately the pressures and variations of pressure within the cylinder without errors due to the elasticity and inertia of the moving mechanism. In an endeavor to eliminate the effects of inertia in the moving element, a means has been devised whereby a successful transformation of pressure variations to electrical variations and of electrical variations to variations in the movement of a beam of light has been accomplished. The latter transformation, by means of an oscillograph, makes it possible actually to see what changes in pressure take place within the cylinder and to make a photographic record of these changes. An indicator embodying these factors is described in this paper.

ELECTRICAL INDICATORS

Two types of indicators that produce an electrical current that varies with the pressure in an engine cylinder have been successful for certain types of indicator work.[1] These are the carbon-pile, or telemeter, type developed by Martin and Caris of the General Motors Research Corporation, and the condenser-transmitter type developed in Germany by the "Deutschen Versuchsanstalt für Luftfahrt," a description of which was published in the D.V.L. year book for 1930. Both of these indicators use an oscillograph as a recording mechanism.

The telemeter type makes use of the principle of the varying conductivity with pressure of a pile of carbon disks. To secure a straight-line response, two stacks are opposed and connected to a diaphragm so that any increase of pressure on one stack accompanies a decrease of pressure on the other. The stacks have resistances of approximately 45 ohms each and are connected as two legs of a Wheatstone bridge. The galvanometer current of the bridge circuit is passed through a sensitive oscillograph. The chief difficulties of this type of indicator are in maintaining a calibration of the instrument which will not change, and in producing a pressure line that is free from vibration.

The condenser-transmitter type utilizes the principle of semiresonance between two oscillating circuits connected to the grid of a tube biased for detection. The detector circuit is detuned slightly so as to operate normally on the steep side of the resonance curve. The condenser transmitter shunts the tuning condenser of this circuit, and since its capacity changes with pressure, the oscillatory circuit is tuned or detuned by action of pressure on the transmitter. The plate current of the detector tube is passed through an oscillograph and a pressure record is thus obtained. In the "D.V.L." indicator, a small diaphragm is exposed to the pressure, and a shunt transmits movements from this to the condenser diaphragm, mounted on the side of an insulated plate remote from the pressure source.

[1] "Indicators as a Means of Improving Aircraft Engine Performance," by F. L. Prescott, *S.A.E. Journal*, 1932, vol. 31, pp. 361–362.

SEMIELECTRICAL INDICATORS

Progressing to the balanced-pressure type, there may be noted the "R.A.E." indicator which is the Farnboro balanced-valve type developed by the Royal Aircraft Establishment of England,[1] and the Bureau of Standards indicators.[1] Both of these operate upon the principle of balancing an externally controlled pressure against the instantaneous cylinder pressure and require an external source of pressure and a vacuum exceeding those to be measured. The contact point on the R.A.E. indicator is a light valve, seating on either side and having a travel of between 0.005 and 0.010 in. from one seat to the other. Upon leaving either seat contact is broken and the primary current of an induction coil is interrupted. A spark passes from the pressure-actuated stylus and punctures a hole in a paper on a drum revolving at engine or half engine speed. By this means, a pressure-time diagram is obtained. The shape of the pressure peak varies from one cycle to another, and for this reason, the high-pressure portion of the record obtained with the R.A.E. indicator is composed of a mass of widely scattered points, through which a line is drawn at one's own discretion. Eliminating this defect appears to be impossible, hence the record loses value. A measurable time is required for the disk valve to pass from one seat to the other. Time is also required to build up sufficient flux in the induction-coil core to cause a spark to pass, thus imposing a definite speed limit, beyond which only the rising side of the pressure record is obtained. With this indicator, low-scale or weak-spring cards can readily be obtained. Some lag due to pressure required to actuate the moving stylus undoubtedly occurs, which renders such low-pressure cards of little value unless taken very slowly.

The Bureau of Standards indicator uses a light steel diaphragm which is supported between two perforated disks and touches an insulated electrode at approximately atmospheric pressure. A timer is driven at half engine speed and closes contact during a brief instant, about two degrees of crankshaft motion. If, during this instant, the cylinder pressure is higher than the external pressure, contact is closed and a click is heard in a telephone receiver. If the external pressure is higher, no click is heard. At the point where the click ceases, the external pressure equals the cylinder pressure during the short period of contact. Thus, a series of points is obtained and plotted against crank angle or piston position, giving a pressure-time or pressure-volume card. The chief objection to the Bureau of Standards indicator is the time required to take data and plot them.

NEW INDICATOR

The indicator herein described was designed with the hope of eliminating the defects of other types of high-speed indicators. It consists essentially of two separate parts; the moving or mechanical element and the electrical element. The cross section of Fig. 1 illustrates the principles of the design. The pressure in the cylinder acting on a small piston in the indica-

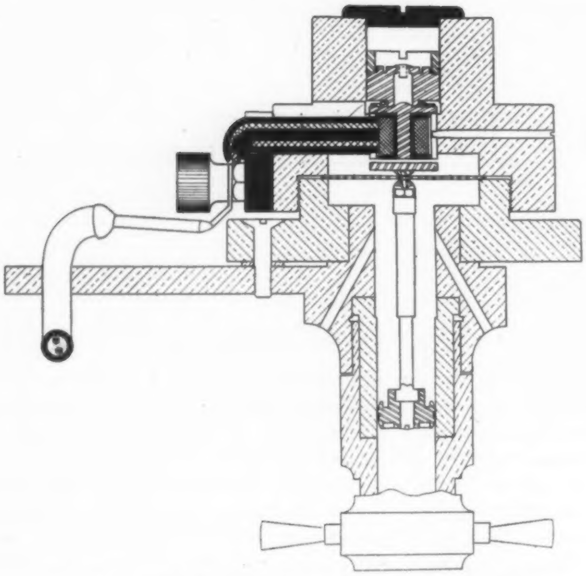

FIG. 1 CROSS SECTION OF HIGH-SPEED INDICATOR

tor is transmitted to a steel diaphragm, the displacement of which actuates an armature placed in the air gap of a small electrical coil. No springs, links, or lever arms which might introduce error are used. The coil is the only electrical feature of the indicator and the air gap is used to maintain a flux linkage with the armature of the mechanical element. Fig. 2 shows the exterior of the indicator.

The electrical coil performs the following functions: (1) It transforms the mechanical movement of the pressure-actuated diaphragm to electrical energy of high frequency; (2) it magnifies the mechanical movement by a maximum ratio of 1000 to 1; (3) it introduces a time element of 2000 pressure measurements per second by using an electrical frequency of 2000 cycles.

Excellent and consistent calibrations have been obtained by the apparatus and an actual indicator card which was taken by means of an oscillograph is illustrated in Fig. 3. This card shows the effect of spark advance at low output using a fuel-injection two-cycle motor.

ADVANTAGES OF THE NEW TYPE OF INDICATOR

The new type of indicator takes a pressure-time card and gives a record of pressure variation with respect to time throughout the entire stroke. It has advantage over the pressure-volume card because (*a*) the "center in" and "center out" positions of that card do not give a true relation of pressure with respect to time, and these points on the card are of importance; (*b*) it eliminates the use of a reducing motion on the engine which is not capable of following the extremely high speeds without introducing an error.

Cards may be observed by the eye, or a photographic record can be made by means of an oscillograph.

Speed indicators are not necessary. From the indicator card shown in Fig. 3 it can be seen that a record of firing from the ignition circuit combined with the standard 60-cycle timing wave gives an accurate means of determining speed. This record gives a means of determining the rate of change in speed in case the card was taken under accelerating or decelerating conditions.

The cards are continuous in form and no time is introduced between cards. Any number of cards can be taken in succession, depending on the length of film used.

Cards can be taken under accelerating or decelerating conditions.

Line *C* of Fig. 3, which is made by the ignition circuit, is proportional in length to the number of crank-angle degrees turned by the engine during each revolution. This is advantageous in principles of design.

The cards may be taken by remote control in that only four wires need be attached to the engine.

MECHANICAL AND ELECTRICAL DESIGN

The indicator is small in size, rugged in design, and free from vibration of any kind. The indicator may be connected directly to the cylinder chamber, or by using a special spark-plug, connection may be made to the indicator. No springs are used and the movement of the mechanical element is small, having a travel of but 0.003 in. for a pressure of 400 lb per sq in. Any desired movement may be obtained for any given pressure by using steel diaphragms of different thicknesses. This gives a means of selecting the period or natural frequency that

FIG. 2 HIGH-SPEED ELECTRIC INDICATOR

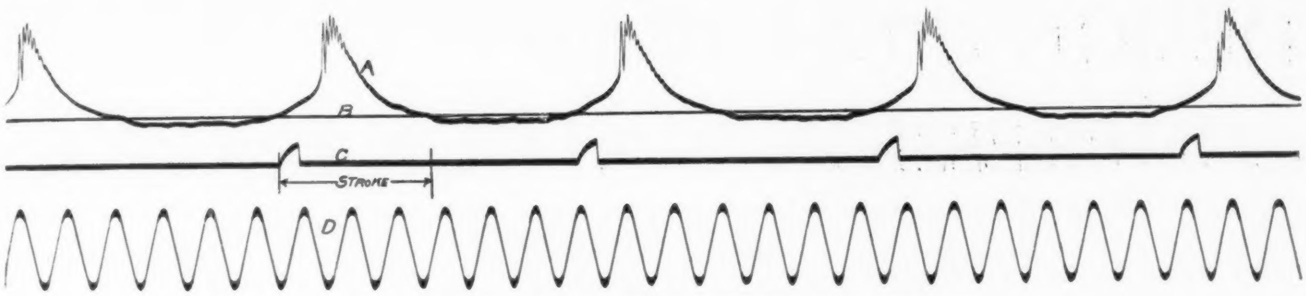

FIG. 3 PRESSURE-TIME CARDS TAKEN WITH HIGH-SPEED INDICATOR

(Two-cycle fuel-injection engine; 554.4 rpm; 25-deg spark advance. A = pressure line; B = atmosphere line; C = ignition line; D = 60-cycle time wave.)

may be desired in the instrument. In order to obtain an accurate record of the ripples on the expansion line of the card, the natural frequency of the mechanical element must exceed that of the ripples caused by the surge pressures upon expansion of the gas within the cylinder. It is therefore necessary that the natural frequency of the moving element exceed the frequency of detonation obtained from fuels having the worst knock characteristics. An oscillogram of the indicator's natural frequency can be obtained from the instrument.

The electrical circuit magnifies the movement of the mechanical element by a ratio of 1000 to 1 for maximum conditions, but may be varied by means of a micrometer adjustment to any desired value of sensitivity within this range. The only connection between the mechanical element and the electrical circuit is air. The principle is that of a high-frequency variable inductive reactance alternating-current bridge circuit. The circuit requires no vacuum tubes and is relatively simple.

In order to take an indicator card with accuracy, pressure measurements should be taken every fractional part of a second. This particular indicator takes 2000 pressure measurements per second, as a frequency of 2000 cycles per second is supplied to the circuit by means of a small portable alternator, the power source of which is a 12-volt storage battery. A filtered circuit gives a direct-current line, indicating pressure as shown on the card. Any number of pressure measurements per second may be obtained by introducing a higher frequency in the circuit. The electrical apparatus is contained in a small wattmeter box and is called the indicator unit. Fig. 4 is a general wiring diagram showing connections to the engine and instruments.

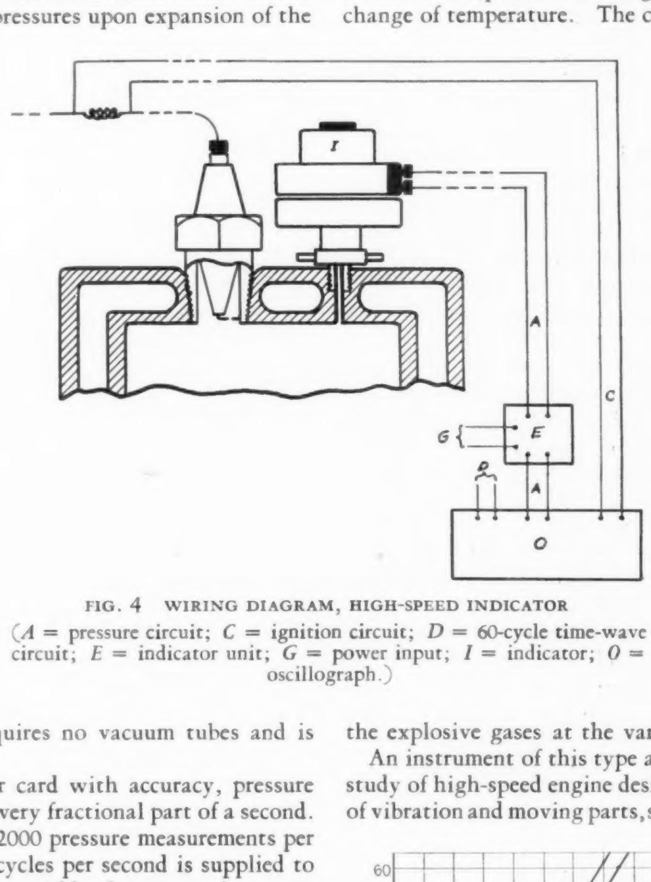

FIG. 4 WIRING DIAGRAM, HIGH-SPEED INDICATOR

(A = pressure circuit; C = ignition circuit; D = 60-cycle time-wave circuit; E = indicator unit; G = power input; I = indicator; O = oscillograph.)

CALIBRATION OF INSTRUMENT

The calibration of the instrument has a straight-line characteristic of oscillograph deflection as a function of pounds per square inch pressure for any desired range, and is consistent as to holding its calibration. Fig. 5 shows actual calibration data taken with the instrument. The calibration is made statically by means of an oil calibrating gage. Temperature has very little effect on the characteristics of the original calibration. The electrical coil in the indicator is the only element which is susceptible to a change in the electrical circuit due to a change of temperature. The combined electrical circuit has an impedance of 15,000 ohms as compared to an impedance of 30 ohms in the electrical coil in the indicator, thus any change in the resistance of the coil which represents two tenths of one per cent of the total impedance of the combined circuit has very little effect relative to the output of the circuit. Under tests the calibration curve shifted parallel to the original curve approximately 3 mm for a pressure of 400 lb per sq in. when the indicator was first exposed to the explosion of the gases within the cylinder. After the indicator has reached a constant temperature, tests can be made at any engine speed and no temperature-correction factor need be applied because the temperature effect on the indicator of the explosive gases at the various speeds is negligible.

An instrument of this type also has many applications in the study of high-speed engine design where an accurate knowledge of vibration and moving parts, such as valve motion, is necessary.

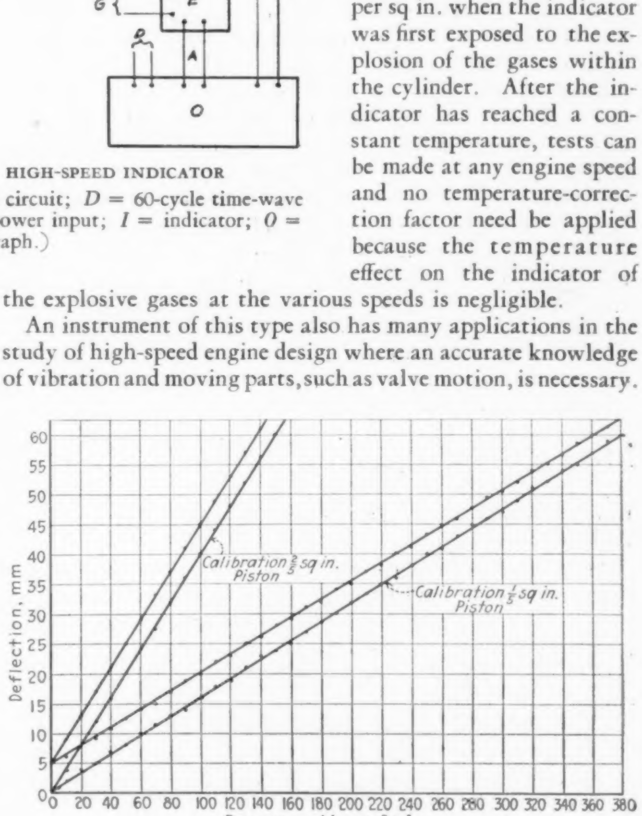

FIG. 5 CALIBRATION CURVES, HIGH-SPEED INDICATOR

DESIGN *of Light-Weight* COMPRESSION-IGNITION ENGINES

By E. T. VINCENT

CONTINENTAL MOTORS CORPORATION, DETROIT, MICH.

THE PRIMARY advantage of the oil engine is its thermodynamic efficiency, which exceeds that of other prime movers. This efficiency is a result of the cycle of operations. Its actual value varies considerably for individual engines, but even the worst is better than that of the nearest competitor while the best recorded is nearly double that of the average gasoline engine.

A secondary advantage of the oil engine is the fact that the oil on which it operates is, at the present time, far cheaper than gasoline, so that marked savings can be shown in operating economy. This reduced fuel cost, however, is purely incidental. Opponents of the oil engine treat it as the major advantage and prove that in a few years it will cease to exist because fuel prices will increase as the demand for large volume grows. However, there appears to be no reason why the price of oil fuel should exceed that of gasoline, as a large demand for the latter will probably always exist and this will tend to stabilize the price situation.

An additional cost factor is taxes. As more oil fuel is used, taxes on it will probably increase. Here again the situation is such that an excessive tax on oil as compared with that on gasoline will not be possible, and eventually, assuming there is a large demand for oil, a price comparable with that of gasoline will probably result.

Prolonged tests have indicated that with present-day high-speed oil engines it is possible to increase the miles per gallon of a heavy passenger vehicle in the ratio of 1 to 1.7, approximately. This difference is chiefly the result of improved economy of the oil engine at reduced throttle. Taking these figures and assuming that a tax is applied to oil in an intelligent manner, the attempt will be made to derive a definite sum per year from all fuels sold for power purposes. For a given mileage 60 per cent more gasoline than fuel oil would be required, so that, to provide an equivalent income, the tax per gallon of fuel oil must be 60 per cent greater than that on gasoline. For example, if the price of both oil and gasoline were 12 cents per gallon and there were a tax of 6 cents per gallon of gasoline, then a fair basis for a tax on the oil would be $9^1/_2$ cents per gallon, making fuel costs 18 cents for gasoline and $21^1/_2$ cents for Diesel fuel. The resulting costs per mile would then be in the ratio of 1 to 1.42, which still shows a good margin in favor of the oil engine.

At present, maintenance of the compression-ignition oil engine is higher than that of the spark-ignition engine because so few of them are on the road. With increased use and experience this difference will be greatly reduced, and eventually maintenance should not greatly exceed that of the gasoline engine.

The long haul with continuous use presents the best field for the Diesel of today and probably for that of the future, since it is in this service that the thermodynamic efficiency will show up to best advantage and any difference in first cost can be amortized readily.

In Great Britain, where a tax of eight pence per gallon of fuel oil has been applied, the London Passenger Transport Board with 800 Diesel-engined vehicles in operation is adding to them at the rate of six to eight per week until all of its 6000 vehicles shall have been converted. The tax increase is estimated at $275,000 per year, and to justify the conversion economically each vehicle must cover at least 22,000 miles per year as compared with 17,000 miles formerly. Since each vehicle covers about 50,000 miles per year, a distinct saving will still be made, despite present high first costs and maintenance.

The foregoing comparisons indicate that if fuel and tax costs are applied in a reasonable and intelligent manner there will still be a place for the oil engine because of its efficiency. Power generation, in the final economic analysis, is a problem of obtaining the required output at a minimum cost, and for many fields of application the compression-ignition engine will provide the answer.

The possibility that prices will get out of control is remote. If gasoline and oil prices differ greatly, one engine or the other will predominate and one fuel will be a drug on the market and therefore cheap. This should stimulate the use of the engine that operates on the cheaper fuel. Should the price of both fuels increase above reasonable limits, coal becomes an active competitor and its use will act to stabilize the market. Therefore, with suitable development, there should be a field for the automotive Diesel, despite fluctuating fuel prices and taxes.

The use of the Diesel engine for rail transportation and switching is well established because, as compared with the gasoline engine, the maintenance is less and the operating economy higher. Most of what follows applies to Diesel engines in rail service, since it is in this field that so much public attention has been concentrated.

GENERAL DESIGN

The general design of oil engines, whether of the high-speed variety or otherwise, is now reaching some form of standardization, as reference to Table 1 will show. The approximate common ratios of the various parts are as follows: Crankshafts, 65 to 70 per cent of cylinder bore; crankpins, 60 to 67 per cent of cylinder bore; piston pins, 30 to 40 per cent of cylinder bore; length of connecting rod, 2 to $2^1/_4$ times stroke; length of piston, $1^1/_2$ times bore.

The general principles of design of oil engines and gasoline engines are similar, with a few exceptions that are easily recognized and can be allowed for if a careful analysis is made of the mechanics of the engine.

Only a few years ago the oil engine was considered an essentially slow-speed machine, chiefly because of our lack of knowledge of combustion. Many engineers believed that droplets of fuel had to undergo a complicated process of heating, gasification, and mixing with air before combustion was initiated, and therefore increase of speed beyond a certain point appeared

Presented at a meeting of the Detroit Section, Detroit, Mich., Oct. 16, 1935, of The American Society of Mechanical Engineers.

TABLE 1 COMPARISONS OF DIESEL ENGINES

PISTONS AND VALVES

Manufacturer	Assoc. Equip. Co.	Assoc. Equip. Co.	Büssig N.A.G.	Deutz	Dorman	Henschel	Henschel	Hill	Mercedes Benz	M.A.N.	Ober-haensli	Saurer	Lanova Simson Supra
Working method	*a*	*a*	*b*	*b*	*a*	*c*	*c*	*b*	*b*	*d*	*e*	*c*	*c*
Speed, rpm	2000	2000	2200	1500	1800	2000	1500	2000	2000	1400	1800	1800	2900
Cylinder bore, mm	108	115	110	120	120	100	110	89	110	140	110	110	76
Valve diam, mm	43	47	47	48	46	36	40	36	38	47	48	48	38
Valve diam./cyl bore	0.38	0.404	0.427	0.4	0.384	0.36	0.36	0.41	0.346	0.336	0.436	0.436	0.5
Piston length/cyl bore	1.5	1.37	1.6	1.35	1.3	1.5	1.52	1.38	1.42	1.44	1.5	1.66	...
Piston material	Sil	Sil	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al
No. compression rings	4	3	4	3	3	3	3	4	4	4	4	4	3
No. oil-scraper rings	1	2	1	2	1	1	1	1	1	1	1	1	1
Piston-pin diam/cyl bore	0.368	0.357	0.372	0.4	0.325	0.35	0.36	0.412	0.35	0.352	0.318	0.328	0.327

1930 and 1933 DIESEL ENGINES

	Rpm	Mean piston speed, m per sec	Brake mep, atm	Power kg per hp
Mean value, 1930	1200	7.2	5.25	12.5
Mean value, 1933	1900	8.8	5.75	6.8
Increase, per cent	58	23	9.5	—45

NOTES: *a* = Ricardo turbulence; *b* = antechamber; *c* = air reservoir; *d* = solid injection; *e* = turbulence chamber.

COMPARISON OF GASOLINE AND DIESEL MARINE ENGINES OF SAME MANUFACTURER

(Gasoline motor value = 100)

Diesel	Rpm	Brake mep	Hp per liter displacement	Weight Kg per hp	Weight Kg per liter	Price per Hp	Price per Liter disp.	Price per Kg
Minimum	84	76	84	120	84	136	132	94.2
Maximum	89	90	94.7	238	94.7	216	200	130
Mean	86	85	88.8	176	88.8	157	155	112

almost impossible. A few did not believe this, and a little clear thinking about the conditions as they then existed should have shown that speed increase would be an advantage.

Some years ago the greatest difficulty was to control the rate of combustion so that it would be slow enough. The immediate conclusion should have been to run the engine faster to keep up with the combustion. Of course, there were limitations set by materials, but it is easy today to see what should have been done.

In view of the pressure rises that can be achieved during combustion, it is safe to say that the oil engine is inherently a high-speed machine, and this speed is not so greatly limited by bearing load as it is in a gasoline engine, for the following reasons:

The bearings of a high-speed gasoline engine are affected chiefly by the inertia loads, which exceed those due to gas pressures, and thus the design of the crankshaft is a function of speed and weight of parts. The crankshaft design affects many other parts of first importance. In the case of a Diesel engine of good design—one intended for long, continuous operation at full load and speed—the gas pressure will always exceed the inertia at the highest speeds in use today. Hence, the design of shaft bearings is a function of the cylinder diameter and not so much the speed of rotation. An actual example will show this.

The curves in Fig. 1 are for engines designed for 2000 rpm. The total weight of reciprocating parts in $8^1/_2$ lb per cylinder, and of the rotating parts, 6 lb per cylinder. The loadings are listed in Table 2.

The figures of Table 2 indicate that almost double the designed speed has to be reached before inertia exceeds the gas

TABLE 2

Engine speed, rpm	1000	2000	3000	4000
Inertia at maximum cylinder pressure, lb	789	3150	7100	12610
Gas load, lb	14300	15900	18400	18400
Acceleration, ft per sec per sec	2990	11960	26910	47840
Centrifugal load, lb	480	1920	4320	7670
Inertia and centrifugal load, lb	—1269	—5070	—11420	—20280
Crankpin load,[1] lb	+13031	+10830	+6980	—1880

[1] Crankpin load is positive in the direction of the gas load.

load. To reach the designed maximum loading during the expansion stroke, a still further increase in speed is necessary. The load during the suction and exhaust strokes, however, would reach the allowable value at about 3000 rpm, and, provided provision is made to take care of the heat flow from the bearing, a 50 per cent increase of speed is possible without overloading the bearings.

The engine under consideration is of the two-cycle type, which modifies the figures, because, since there is no suction or exhaust stroke, the inertia at top center is cushioned at each stroke by gas pressure. The loading resulting from speed therefore occurs at bottom crank position and reaches a value equal to the designed bearing load at 3300 rpm. Since the inertia load is not equal to the gas load at designed speed, it would be possible to increase the weights of the reciprocating parts and thus reduce the maximum bearing loads at this speed. This is generally true of oil engines; the heavier the parts the lighter the crankpin load.

This sample analysis of bearing loads does not, of course, cover all of the high-speed characteristics of the oil engine but shows that, provided the combustion phase can be provided for, which has already been discussed, the average engine of a given design can usually be operated at overspeed with-

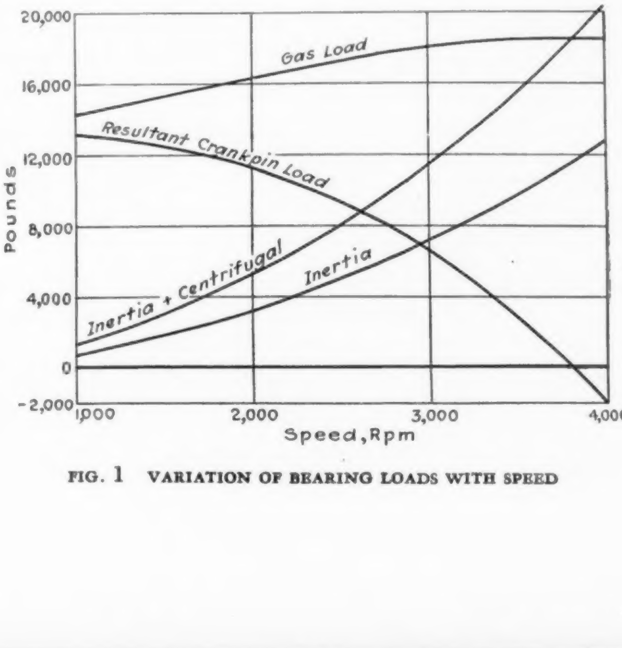

FIG. 1 VARIATION OF BEARING LOADS WITH SPEED

out much difficulty as compared with a gasoline engine, and tends to support the author's contention that speed *per se* is no definite handicap to the compression-ignition engine. Whether a market exists for a real high-speed engine will be left for some one else to determine.

The effect of reducing load on the running gear with increased speed is not a great reduction of weight, since the heads, hold-down studs, and crankcase are unaffected by the inertia forces and they have to carry the total gas load at all times. Since these members, particularly the crankcase, account for a large proportion of the engine weight, careful design and modern materials and technique are necessary to produce a successful light-weight engine.

Recently, the use of the welded-steel crankcase has been widely advertised and great reduction in weight has been claimed for it. At first sight this appears true, but some of the resulting engine weights are far above what was achieved many years ago in successful engines having cast crankcases. Therefore, this type of construction either is not all that is claimed for it, or has not been carried to its logical conclusion as warranted by the materials employed.

In such a structure as a crankcase it is realized that load calculation is of little consequence in the design, and with an assumed load distribution suitable sections, based on safe stresses, would be unsatisfactory for other reasons. With all of this uncertainty, however, a welded-steel crankcase should be as light if not lighter than one of cast metal. A few figures may show that this has not been achieved in some engines at least.

A four-cycle engine designed about 1923, one which has seen successful service since that time in rail-car operation, had a cast-steel crankcase. The engine, of 200 hp at 800 rpm, weighed, complete with all accessories, less than 14 lb per hp, while the crankcase alone weighed about 5 lb per hp. Experience with these crankcases showed that they were amply strong and stiff for the work they had to do. In fact, it has been said that the engines were better than similar engines weighing considerably more. Perhaps this also illustrates that weight itself is not of major importance.

If it is possible to cast a case for a four-cycle engine operating at only 800 rpm and weighing 5 lb per hp, then it seems reasonable to expect that a high-tensile welded case for a two-cycle engine will weigh considerably less than this amount. If not, something is wrong with the design or with the contention that greater power per pound is possible with a two-cycle than with a four-cycle engine. Examination of the few figures that have been published indicates that this crankcase weight of 5 lb per hp is exceeded by quite a margin in most modern engines.

The cylinder arrangement has an important effect on crankcase weight. The engine already referred to was of the in-line type and, of course, should only be compared with other engines of the same type.

The reduction in weight achieved by the V engine and other types results chiefly from the saving in the weight of the crankcase and crankshaft, and with engines of this class still lighter cases should be expected. Probably, the radial engine makes possible the greatest weight reduction. Welded-steel crankcases of heavy design have been built for engines of this class that weigh less than 1 lb per hp. If real weight reduction were attempted, this could probably be reduced to $^3/_4$ lb per hp. With this type of design there is reason to believe that a cast crankcase, or one of combined welded and cast design, would prove to be the most economical from a weight standpoint.

One interesting construction of about 1910 is found in an early Vickers submarine-engine construction with a crankcase built up of plates riveted together. This crankcase would be light compared with many modern so-called light-weight engines. The design was probably far ahead of its day and of the technique available. However, many of these engines were built and operated at sea for long periods during the World War.

Considering previous achievements, a good crankcase design for a two-cycle engine of the in-line type should be capable of being produced for a weight not exceeding $3^1/_2$ to 4 lb per hp, if high-tensile steel were used, and should have sufficient stiffness and rigidity to carry whatever loads occur in service.

In the case of radial engines there is no reason why a crankcase weighing about $^5/_8$ lb per hp cannot be obtained with good design embodying a combined welded and cast structure. The art of welding crankcases is probably still in its infancy and great things can be expected of it, if welding is not to be abandoned in favor of casting.

PISTON DESIGN

From some angles the design of a piston is one of the simplest of all the problems of the engine, yet perhaps more difficulties can be traced to defects in this part than in any other.

To provide a design which adequately fulfills the requirements may appear at first sight a rather tough assignment. In actual practice it is only necessary to satisfy one or two simple fundamentals in order to produce a design that adequately meets all demands.

Some consideration has already been devoted to inertia effects on bearing loads and it has been shown that an oil engine may employ heavier reciprocating parts without adding to the bearing loads. In fact, up to a certain speed, these loads are less.

Gasoline-engine design progressed rapidly with lighter and smaller reciprocating parts and was even carried a little too far. Today distortion of cylinder walls and pistons is receiving considerable attention. This practice of using light parts in high-speed engines was also followed in some instances in the high-speed Diesel. However, as has been pointed out, the same reason does not exist for it in the oil engine and it is considered a definite disadvantage, as difficulty has resulted, not only in operation but also in starting.

Let us consider in greater detail the conditions under which an oil-engine piston operates as compared with those of a spark-ignition engine. In the former the maximum cylinder pressure is almost doubled while the maximum gas temperatures are also higher, although not in proportion to the pressure. However, since the cycle is more efficient and there is less heat loss to the jackets, it stands to reason that the mean temperatures of the parts must be lower. The general result is that the piston will tend to wear better, owing to lower temperatures, but the rings have a harder duty to perform to prevent blow-by.

In considering ring and cylinder wear, we can obviously eliminate variations in piston velocities, since, if velocity had a major effect, the maximum wear would be expected near the middle of the stroke rather than at the ends. Lubrication can also be dismissed, since, with a reasonable oil consumption, little can be done without increasing the amount burned above allowable limits, which is to be avoided provided another solution of the wear problem is available.

Tests have shown that the pressure in the back of the top piston ring approaches 100 per cent of the maximum cylinder pressure and there is little to be done about it. The other rings gradually break this down and leakage is prevented. Blow-by is a measure of the effectiveness of rings, though not a complete indication, since this records the effect of cylinder distortion as well. However, in a given engine this latter should be more or less constant and relative results should be obtained with other ring combinations. Blow-by is particularly im-

portant, since it eventually results in stuck rings, burned pistons, and difficult starting. Some designers, particularly in slow-speed engines provide a number of rings in an effort to seal the gases but they do not seem to be any more successful than those using only two or three rings, and, because of the reduced frictional losses, the lesser number of rings is to be preferred. This is particularly true because tests have shown that additional rings do not eliminate a hot piston, as was at one time thought to be the case. It is now considered that most of the heat passes to the jacket through the piston itself and not into the rings and then into the jacket.

Ring width is another point on which differences of opinion still exist. It is common practice in many instances to fit an oil-engine piston with a wider ring than would be used in a gasoline engine of a corresponding size. There seems to be no logical reason for this, since the wider the ring the greater the gas load. Ring tension is negligible when compared with the gas pressure behind the ring and need hardly be considered. In so far as tests with wide rings go, no effect upon the gas pressure behind the ring is noted, if anything, the wider the ring the greater the pressure.

On certain engines the author used relatively narrow rings. These proved to hold compression quite successfully. When it was indicated that there might be additional advantages in their use, tests to determine frictional losses and blow-by under certain conditions were conducted. Subsequently, some figures reported by H. Wright Baker[1] confirmed these tests and also recorded additional information regarding the effect of narrow rings on piston temperatures. Table 3 shows his results together with some measurements taken by the author. In each case it will be noted that there was an apparent reduction of frictional losses with the narrow ring, accompanied in the author's tests by a reduction in blow-by.

The fact that with the narrow ring there was a reduced piston temperature also confirms a previous statement that the rings do not transmit most of the heat, the piston area being more effective in this case. The oil film between the ring and the cylinder wall may have some influence upon the heat flow from the piston. This may change considerably with the width of ring and account for temperature changes.

When considering aluminum pistons the light-weight design similar in some respects to the gas-engine piston has little to recommend it for oil engines.

[1] "Piston Temperatures on a High-Speed Air-Cooled Petrol Engine," by H. Wright Baker, *Journal*, Institution of Automobile Engineers, vol. 3, no. 4, January, 1935, pp. 47–78.

The thin-section piston with rings close to the crown is going out, even in gas engines. The author's first experience with aluminum pistons in oil engines was some eighteen years ago in the case of a marine engine, in which a change was made from iron to alloy. The iron piston was of the customary heavy construction so that the saving in weight by using alloy would have been great if every advantage afforded by the metal had been taken. This was not done, however, since sufficient gain could be made without risking too much. Hence the design was massive with an extremely thick crown. Strange to say, for such a radical experiment, for those days, as fitting a cylinder $14^1/_2$ in. in diameter with an uncooled alloy piston, the design was a perfect success so far as cooling and general operation were concerned. Incidently, the piston was fitted with rings that were considered narrow for the engine size. Undoubtedly, from our present knowledge, the alloy, hardness, and heat-treatment were all wrong, but it worked and did the job well. This and subsequent experiences have influenced the author's designs so that they have been on the heavy side in so far as pistons are concerned.

Excess metal in a piston affects bearing loads and is an advantage as already pointed out. A heavy crown and a heavy ring belt are advisable in an oil engine.

Confirmation of this design is again obtained from Baker's paper[1] where experiments with ribbed and unribbed pistons were reported as follows:

	Temp gradient center to $^1/_4$ in. of edge, C
(1) Ribbed piston	51
(2) Same piston, ribs cut away	63
(3) Unribbed piston same weight as no. 1...	31

Apparently, as Baker states, although the removal of the ribs is detrimental, their replacement by an equal weight of metal in the head results in a reduction of the temperature gradient by 40 per cent. The addition of ribs to a crown of any thickness will undoubtedly result in a cooler piston, and in this connection consideration must be given to the crankcase ventilation.

Beyond a certain thickness, it is conceivable that ribs may be more effective than a corresponding addition to the thickness, provided ample crankcase circulation is maintained, since the ribs can dispose of their heat to the circulating air better than a plain surface. If ribs are to be of any use, baffles must be avoided in the crankcase and free circulation of oil and air to the piston permitted. In an effort to provide ample radiating surface, the ribs can be placed too close together, which prevents easy air circulation.

Summarizing the conditions for successful operation, it can be stated that

(1) Ample sections in the head and ring belt are necessary.

(2) The top ring should be well away from the top of the piston to prevent rapid wear and sticking.

(3) Narrow rings are preferred.

TABLE 3 EFFECT OF RING WIDTH

DATA BY BAKER[1]

Test no	1	2		3	
Number of rings	3	2	1	2	1
Width of rings, in	$^3/_{64}$	$^3/_{32}$	$^3/_{64}$	$^3/_{16}$	$^3/_{64}$
Total ring closing pressure, lb	4.2	6.0		9.4	
Piston temperature					
Center, C	215	250		260	
Edge, C	177	203		199	
Temperature gradient, C	38	47		61	
Brake horsepower	10.46	10.01		9.71	

DATA BY VINCENT

Revolutions per minute	600				1250				1500			
Ciylnder pressure, lb per sq in	0	200	400	600	0	200	400	600	0	200	400	600
Wide rings												
Loss, hp	0.96	1.34	1.64	1.70	3.21	3.75	4.18	4.75	4.91	5.25	6.0	6.25
Blow-by, cu ft per min	0	2.47	4.49	7.33	0	2.10	4.44	6.91	0	2.0	4.7	6.98
Narrow rings												
Loss, hp	0.8	1.16	1.46	1.58	3.33	3.46	3.85	4.4	4.52	4.57	4.87	5.3
Blow-by, cu ft per min	0	1.78	4.0	6.31	0	1.64	3.75	6.25	0	1.62	3.64	6.03

(4) Blow-by must be prevented both by piston, ring, and cylinder design, it being important to prevent distortion of piston and cylinder walls.

The design of the other engine components is more or less conventional, with the possible exception of the valve timing. In general, the valve functions differ considerably from those used in gasoline-engine practice, particularly the inlet closing.

Since air only is drawn into the cylinders, it is not necessary to hold the inlet valve open to take advantage of the evaporation of gasoline in increasing the volumetric efficiency. As a result it is a general practice to close the inlet much earlier than is usual with spark-ignition engines. The exact point for a given design is difficult to predict with accuracy, as much depends upon manifolding, valve area, induction-pipe area, and engine speed. However, as a rough guide it is fairly common to close the valve about 20 to 25 deg earlier than in a comparable gasoline engine.

Overlap of inlet and exhaust valves is also not a factor in obtaining smooth operation at small throttle openings, and hence can be set to give the highest volumetric efficiency.

Torsional vibration crops up in all engine design but is of particular importance in the case of the Diesel engine, chiefly because of heavier parts and greater disturbing forces.

Without attempting to deal with the calculation of periods, one phase of the problem not usually appreciated may be mentioned. Torsional vibration affects crankshaft design chiefly, but if the most is to be made of a given mass of material, this problem should be given some thought before even the cylinder size is decided upon. For a given horsepower, mean pressure, and speed, the cylinder size in cubic inches is determined, but this can be divided into different stroke-bore ratios, which, in turn, play their part in the critical speed of the shaft.

The general opinion appears to exist that a small high-speed Diesel must have a large stroke-bore ratio in order to secure good combustion characteristics. Analysis of such an engine usually results in much lower critical speeds than in engines with a small stroke-bore ratio, because the ratio of weight to shaft stiffness is greater. The engine with a small stroke-bore ratio has a far huskier shaft whose stiffness depends upon the fourth power of the diameter while the weights only change roughly as the cube of the dimensions. Thus a gain in stiffness results and fewer critical speeds occur in the range of normal operation by using a small stroke-bore ratio. This should be kept in mind when first deciding on engine size.

CYLINDER-HEAD DESIGN

One phase of Diesel-engine design which in the last few years has received more attention than any other is that of producing good combustion characteristics. These efforts have been chiefly centered upon the cylinder head, and undoubtedly this part of the engine structure does play an important part in the results achieved.

Modern developments are almost exclusively improvements of old ideas. It may be that some one will come forward with an idea that will improve simultaneously both power output and fuel economy of the oil engine. We have at present ideas that would improve power or economy, but none combines these two to the best advantage.

Strangers to the oil-engine field would be led to believe that turbulence is a modern development while actually it is as old as oil engines themselves. About 1890 Ackroyd Stewart realized that efficient mixing of air and fuel by means of air velocity was desirable. What we have done is to apply this principle scientifically and with a greater knowledge of what we are doing from many angles other than air velocity only. Incidently we have instruments by which to determine what we are actually accomplishing.

It may be argued that the velocity of air through the valve created turbulence in any case in the earliest engine. This is so, but the effects were unknown. In fact, the engineer of earlier days probably did not realize that this effect existed until experiments on explosions in closed vessels were carried out with and without turbulence. Even some of these tests under certain conditions failed to indicate the pronounced effect of turbulence.

Modern progress has resulted from realizing to a greater extent what is taking place in the combustion chambers and then measuring relative effects. Ricardo and his associates have recently published much on the turbulence effects in sleeve-valve engines and we now have such terms as "swirl ratios," added to the nomenclature, particularly as applied to the vortex combustion chamber. The rate of swirl in sleeve-valve engines is under ready control over wide limits by simple control mechanisms, and these engines without valves in the head presented an ideal set-up for such experiments. Ricardo has demonstrated that good results over a wide speed range are possible.

There are many variations of turbulence control by means of combustion-chamber design but they all arrive at somewhat the same results by different methods.

It is still true that the direct-injection engine, or an engine in which the fuel is fed directly into a single-cell combustion chamber in open communication with the piston, is the best performer on a combined power and economy basis. Ricardo's vortex chamber is of this type. Divided chambers of either the pre-combustion or air-storage type fail on an economy basis. This seems reasonable since the air and fuel do not mix as early in the stroke; therefore late combustion results.

So far we have only touched the fringes of this subject. Much remains to be done. The author believes that an open-chamber engine with proper turbulence control by some means yet to be found will supply the nearest approach to Diesel economy with gasoline-engine power.

There is not such a difference as appears at first sight in the actual continuous-load rating of the gasoline and the Diesel engine. We are so accustomed to looking at gasoline-engine performance figures obtained from rich mixtures and corrected for temperature and pressure that we have a false impression on the outputs. It is certainly true that under test conditions these powers are recorded, but no manufacturer will sell engines to deliver that power for other than automotive purposes. Immediately after one of these engines is adapted to marine work its power is cut some 20 to 25 per cent because it is well known that under the conditions of full load demanded by marine application the engines do not perform at their maximum outputs. When used for automotive equipment the engines are called upon to develop this maximum power so seldom that in most instances no damage is done.

In the case of the Diesel operated at the maximum power a brake mean effective pressure of at least 120 to 125 lb per sq in. can be obtained in an engine of good design, which is equal and probably superior to that which can be obtained with the average automotive engine of comparable speed. However, every one holds up his hands in horror because these engines emit smoke. In certain cases this in itself is of no danger to the engine but it just does not look well. Actual engine temperatures are probably less than in a gasoline engine operating at full power and less damage is being done to the parts. That the parts of the gasoline engine are highly heat stressed and wear rapidly does not show in the usual short tests given.

(*Continued on page 306*)

EMISSIVITIES *of* REFRACTORY MATERIALS

By R. H. HEILMAN

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REFRACTORIES at high temperatures are generally conceded to have emissivity values, roughly, between 0.8 and 0.98. The results of experiments conducted by the author in 1934[1] indicated that these values are much too high for some refractories.

In view of the fact that some investigators have questioned these results and due to the lack of more definite information in the literature, it was decided to continue the investigations, using a different method for determining the surface temperatures. At the suggestion of H. C. Hottel a fine-wire platinum-rhodium couple was used in checking former determinations.

It is a well-known fact that for low temperatures color has no influence on what is termed "black" heat radiation, as distinguished from solar radiation, where color has a tremendous influence. The reflection of solar radiation from white surfaces is as high as 75 to 80 per cent, whereas the reflection of solar radiation from black surfaces is as low as 2 per cent.

Since white surfaces have an emissivity value as high as 0.95 for low temperatures and as low as 0.2 for temperatures corresponding to the temperature of the sun, there should be some temperature in the industrial range of temperatures where the emissivity of white surfaces will start to decrease.

The results of this investigation confirm that of the former one in that the emissivity of a white surface starts to decrease at the comparatively low temperature of roughly 400 F.

APPARATUS

The thermopile used in this investigation has been described in a previous publication.[2] For temperature above around 800 F, it has been found advisable to use a long baffled tube in front of the thermopile so as to limit the angle of vision.

A platinum-platinum 10 per cent rhodium couple made of wire 0.002 in. in diameter was used in measuring the surface temperature of the various samples. A couple consisting of wire 0.001 in. in diameter was first used and was found to give substantially the same surface temperatures as the wire 0.002 in. in diameter. The 0.001-in. wire proved to be very fragile and was, therefore, replaced by the heavier and stronger thermocouple. The 0.002-in. wire proved to be none too strong for this type of work.

The fine-wire couple was stretched across the face of the material being tested and was held tight against the surface by means of a small weight attached to each thermocouple wire.

Each thermocouple wire passed through an insulating bushing in a brass holder and over an insulated pulley. The brass holders were movable in a horizontal plane, the movement being controlled by inside micrometers which permitted the thermocouple to be moved toward or away from the face of the sample by 0.001-in. intervals. By means of this arrangement the temperature gradient through the air adjacent to the surface could be measured. It was found as expected that the temperature dropped rapidly from the hot surface, the greater portion of the drop taking place in the first half inch.

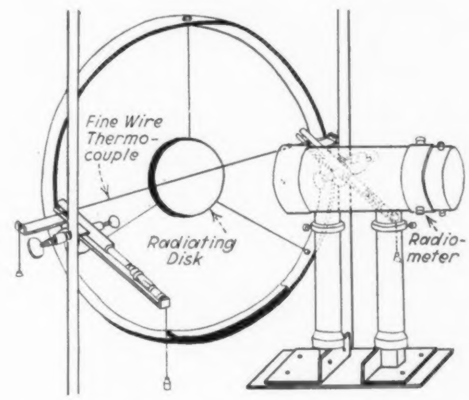

FIG. 1 APPARATUS USED IN EMISSIVITY DETERMINATIONS

It was also found that the air was very turbulent in this relatively thin film of air.

The apparatus is shown diagrammatically in Fig. 1.

CALIBRATION OF SURFACE COUPLE

The fine-wire couple was calibrated for true surface temperature by placing it against the surface of a silver disk. The disk had chromel-alumel couples peened into its surface, which gave the true surface temperature. The fine-wire couple was also calibrated with a steel disk in the same manner. The calibration curve was the same for the silver and steel disks. However, after running a number of emissivity tests on various refractory materials using the calibration curve obtained on the silver and steel disks, it was found that this calibration was not accurate for refractory materials.

The calibration was then obtained by measuring the temperature drop through a film of refractory material applied to the surface of the silver disk with a brush. The chromel-alumel couples were used to measure the temperature of the silver disk, and iron-constantan couples under a thin strip of asbestos tape gave the temperature drop through the refractory. Knowing the conductivity of the asbestos tape and the rate of heat transmission from a small vertical surface, it was possible to calculate the conductivity of the refractory material by the trial-and-error method.

Then, knowing the conductivity of the refractory material, it was possible to calculate the surface temperature of the portion exposed to the thermopile and not covered with any asbestos tape.

[1] "Heat Transmission Through Bare and Insulated Furnace Walls," by R. H. Heilman, Trans. A.I.Ch.E., vol. 31, 1935, p. 165.

[2] "Surface Heat Transmission," by R. H. Heilman, Trans. A.S.M.E., 1929, paper FSP-51-41, pp. 287–302.

Contributed by the Process Industries Division and presented at the Annual Meeting, New York, N. Y., Dec. 2–6, 1935, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Probably a slight error exists in assuming that the thin strip of asbestos paper has the same rate of surface heat flow as it would have if the whole refractory surface were covered with asbestos tape.

However, the error involved in calibrating the surface couple by this method is probably slight and the accuracy of the calibration is substantiated by the emissivity of approximately 0.97 obtained on the black refractory surface at temperatures above 600 F.

In using the calibration curve of the thin platinum-rhodium couple in order to obtain consistent results, it is necessary to plot another curve of temperature drop through the refractory as a function of plate temperature and use this curve in conjunction with the calibration curve for the couple. This results from the fact that the surface couple varies at times in the electromotive force developed for a given surface temperature. Owing to the fact that the emissivity is proportional to the fourth power of the absolute temperature, it is essential that the surface temperature be determined as accurately as possible, and it is also important that the entire surface "seen" by the thermopile be at a uniform temperature.

EMISSIVITIES OF REFRACTORY MATERIALS

On account of the great difficulty encountered in measuring the emissivity of refractory materials, it was decided during this investigation to limit the temperature to around 1500 F. All the refractories and high-temperature paints were placed on a silver disk to insure uniform temperatures and the disk was bulged slightly outward at the center to insure good contact with the thermocouple stretched across the surface of the refractory. The silver disk was in contact with an electrically heated plate.

The refractories and a small amount of bonding material were ground in a ball mill, enough water was added to give a consistency of thin paint, and this was then applied to the silver disk and dried. The refractory was not fired onto the disk and the temperatures obtained during the tests were not high enough to fire the refractory.

It is believed that this method will give substantially the same emissivities as would be obtained on the refractories themselves in the brick form. There is apparently no appreciable difference in the emissivity of a relatively rough brick surface as against the smooth surface obtained from the same brick by grinding in a ball mill. However, there is a difference of about 15 per cent between the ground refractory and a glossy surface such as a high-gloss enamel or a fired enamel of the same color.

Fig. 2 represents the results of some emissivity determinations on various high-temperature paints and on several refractory materials. These curves represent the averages of a great many tests and for this reason are considered to be fairly reliable. The dotted curves are taken from a former paper[1] and were obtained with a different arrangement for measuring the surface temperatures and with a smaller angle of vision of the radiometer.

These tests indicate conclusively that color has a marked influence on the emissivity of surfaces at temperatures above 500 F. From the results of this investigation it is also apparent that the chemical composition of the material has considerable influence on the emissivity. The curves for the white paint and the white refractory differ appreciably at 1000 F. The fact that the light-buff refractory has a lower emissivity than the white paint can possibly be explained by a difference in chemical composition. The composition of white paint was not known. The light-buff refractory was high in alumina and the white refractory shown in the dotted line consisted of equal parts of alumina and silica, while the refractory shown in the solid curve consisted almost entirely of alumina.

An inspection of Fig. 2 indicates that the emissivity decreases with increase in temperature for all the colors of refractory materials and paints investigated with the exception of black. The white paint, the white refractories, and the light-buff refractory show rapidly decreasing emissivity with temperature increase.

This fact should have an important bearing on the design of various high-temperature equipment. For example, the muffles of electric furnaces should prove more economical if made from a dark refractory or a refractory material that has been artificially darkened than if made from light-buff-colored refractories which seem to be the usual practice. The dark refractory, having a much higher emissivity coefficient than the light-buff one, should transmit the radiant energy to the charge more rapidly, and especially so during the period when the charge is relatively cool. As the charge approaches the temperature of the muffle the emissivity coefficient of the muffle will be relatively unimportant as the furnace walls will then be radiating under approximately black-body conditions.

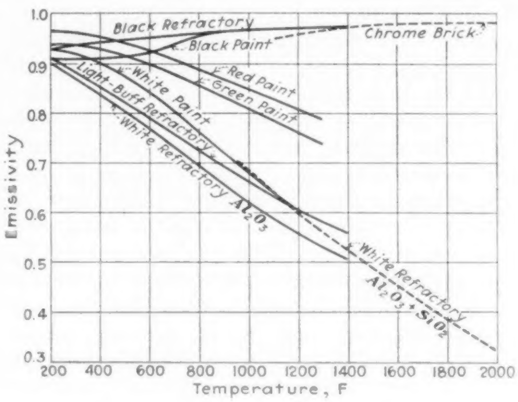

FIG. 2 EMISSIVITIES OF VARIOUS SURFACES

Similarly, a dark refractory should prove more economical than the light-colored silica brick usually used in steel-melting equipment. This should be especially true where nonluminous flames are used. Where luminous flames are used, the radiation from the furnace walls would probably be largely absorbed by the flame, and the flame would transmit radiant energy to the charge under practically black-body conditions.

The operating conditions, such as type of furnace and character of flame, should govern the use of the most suitable refractory. When a furnace is operated where slagging and wearing down of the refractory do not exist, the desired emissivity should be obtained by a light surface coat on the refractory surface. For other cases it should be possible artificially to change the color of the refractory throughout. There are many instances where it is desired that the charge in a furnace be brought up to temperature very slowly. In some cases the use of light-colored refractories or light-colored saggers should result in a lower rate of radiant-heat transfer, especially when the temperature of the charge is considerably below that of the furnace. The rate of heat flow is naturally greater when the temperature difference is large and the use of lower-emissivity materials should counteract to some extent the relatively high rate of heat transfer.

ACKNOWLEDGMENT

In conclusion, the author wishes to thank R. W. Ortmiller, who has assisted in preparing some of the refractory surfaces.

GAS WELDING OF CLASS-1 PRESSURE VESSELS

By G. W. PLINKE

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WITH THE adoption in 1931 of the A.S.M.E. Code for Unfired Pressure Vessels and Power Boilers certain standards were established for the physical properties of weld metal in steel-plate construction. Three classifications were determined which were originally designated as Class 1, Class 2, and Class 3. In Class 1 the highest weld qualities and most stringent requirements of construction were specified, including stress relieving of the entire vessel and X-ray examination. The highest operating fiber stress was permitted for this class of construction and no limitations were placed on pressures, temperatures, or service conditions. The welding of power boilers was limited to this class of construction.

In the two other classifications the weld quality and construction requirements were somewhat reduced with a reduction in permitted operating fiber stress, and limitations of the pressure, temperature, and service conditions.

EARLY EXPERIMENTS

During the early attempts to perfect the applications of welding to pressure-vessel construction to meet Class-1 requirements, oxyacetylene welding was somewhat neglected and its possibilities overlooked. This can probably be accounted for by the fact that most of the construction in this class required thicknesses above which the oxyacetylene process appeared to be commercially applicable. Then, too, the electric process indicated greater economy and ease of securing the required physical results with multilayer deposit. The oxyacetylene process was therefore confined in application to construction equivalent to Class-2 requirements and no particular attention was paid to developing a procedure to accomplish the physical properties specified in Class-1 construction.

After several years of experience fabricating welded pressure vessels and power boilers in accordance with Class-1 construction, using the coated-electrode electric-arc process with the required special technique of control, we began to make some investigations regarding the possibilities of oxyacetylene welding. Numerous tests were made to determine the physical properties of the weld metal using regular gas-welding procedure. The early results showed that the tensile strength was generally satisfactory but the ductility, particularly on plate thicknesses above $^1/_2$ in., was not sufficient to meet Class-1 Code requirements.

To overcome this difficulty various types of experimental welding grooves were employed. Best results in the heavier plate thicknesses were obtained with the double-vee groove, with the U-type groove showing good possibilities in plate thicknesses from 1 in. upward. The U-type groove, however, required a special technique, and care had to be exercised to prevent the molten metal from running in front of the puddle and causing laps.

In experimenting with the various types of grooves, it was found that laps and nonfusion along the side walls could be entirely overcome. Laps were frequently found where the operator changed his welding rod and in starting up again failed to get the parent metal to a sufficiently high temperature to fuse properly with the newly deposited metal. Nonfusion was largely due either to welding at too great a speed and neglecting to notice whether the metal was actually fusing into the side walls, or to the operator's depositing too heavy a layer of weld metal in one pass in the groove.

FLAME ADJUSTMENT AND CONTROL IMPORTANT

Another variable investigated which seemed to give a definite improvement in welding was the proper adjustment and maintenance of the type of flame employed. Prior to this investigation a so-called neutral flame had always been used. However, it was found that a reducing flame, or one with a slight excess of acetylene, materially improved the ductility of the weld metal and such defects as porosity or oxide inclusions were practically eliminated. Proper regulation of the flame was then carefully studied, and steps were taken to govern the stability of the flame so as to keep it as nearly constant as practical. Numerous test plates were welded, stress relieved at 1200 F, and X-rayed. The exographs of these welds showed exceptionally good quality.

The proper type of flame in gas welding causes a protecting gas envelope around the molten metal and prevents the formation of nitrides and oxides in the weld

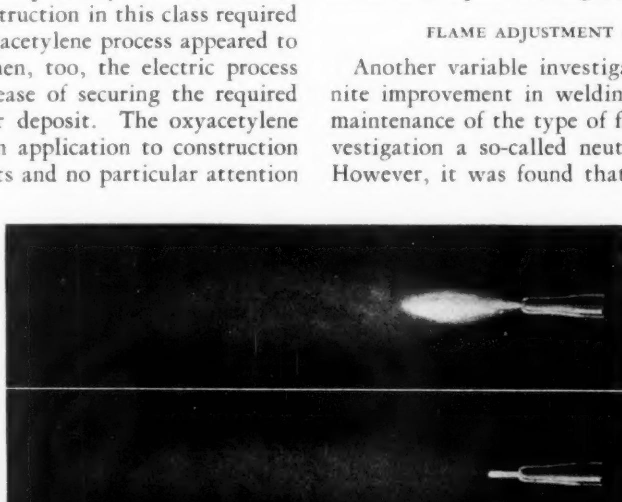

FIG. 1 THE THREE TYPES OF OXYACETYLENE FLAMES

(Top: Reducing or excess-acetylene flame. Center: neutral oxyacetylene flame. Bottom: Oxidizing flame. A slightly reducing or excess-acetylene flame was found to be the most satisfactory.)

Presented at the 36th Annual Convention, Cleveland, November 12–15, 1935, of the International Acetylene Association.

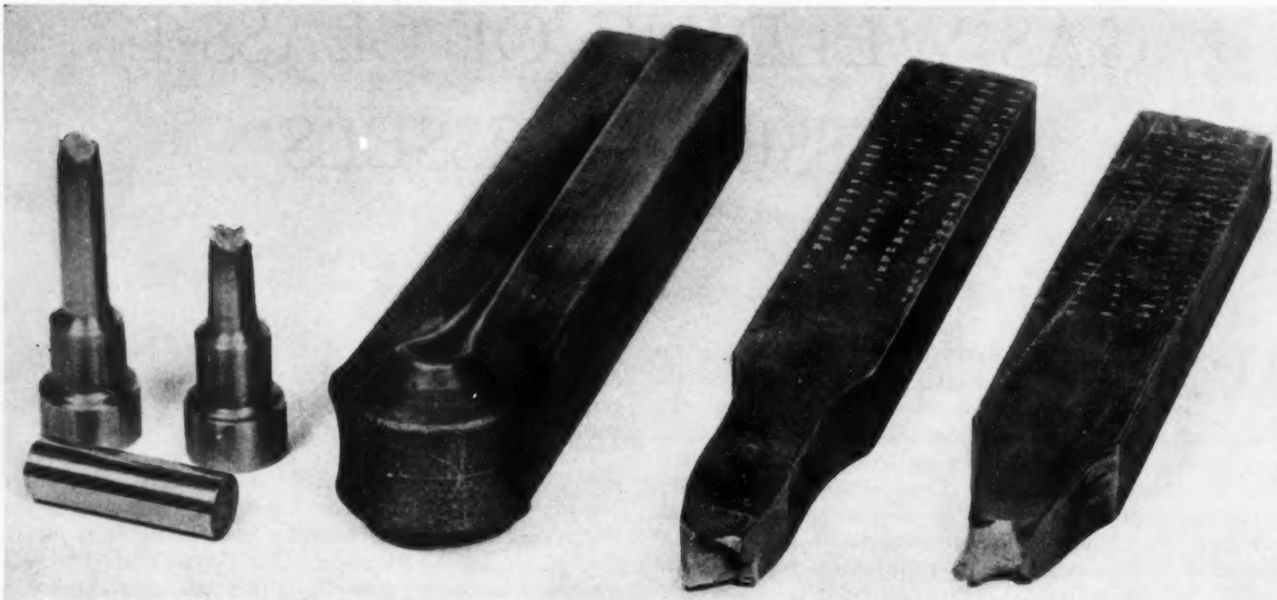

FIG. 2 TEST SPECIMENS COMPLYING WITH A.S.M.E. CLASS-1 REQUIREMENTS

(Left: This all-weld metal specimen showed 21.5 per cent elongation. Later developments brought this figure up to 37 per cent. Center: Bend elongation of 75 per cent was attained at the welded joint. Right: Tensile strength was quite satisfactory on reduced-section tests.)

metal that result from infiltration of contaminating gases much the same as does the coating on the electrode used in electric-arc welding. Fig. 1 illustrates types of flames normally used in gas welding. The flame used to produce the high-quality welds referred to is a modification of the reducing type of flame illustrated.

TESTS REVEAL SPLENDID CHARACTERISTICS

Consideration was also given to the effect of subsequent heat-treatment for grain refinement. Heating above the critical temperature for recrystallization of the weld metal and heat-affected zone naturally gave a considerably finer grain structure. Although the ductility was somewhat improved through this procedure, satisfactory results were obtained without employing it. Oxyacetylene equipment for locally heat-treating the welds was not available, and, furthermore, the problem of controlling distortion caused us for the time being to eliminate this operation.

The final physical tests revealed weld metal which was of high quality and generously met all the requirements of the A.S.M.E. Code for Class-1 welding. An encouraging fact was the consistency of results as shown by repeated tests. Fig. 2 is from photograph of actual specimens on completion of test. Table 1 gives test data which fulfill all Code requirements.

It will be noted that the average value for the Charpy impact test was 25.6 ft-lb. This test, taken from 12 different specimens, showed results from 22- up to 32-ft-lb Charpy 10-mm-square impact specimens. Although the A.S.M.E. Boiler Code does not require Charpy impact tests, this property of the welded joint was investigated because of its significant value.

To demonstrate further the high quality of weld developed by this gas-welding procedure the microstructure of the weld metal, the fusion zone and adjacent to the fusion zone were carefully studied. Freedom from defects including laps and nonfusion is illustrated by the photomicrographs shown in Fig. 3.

It is evident that the welding has altered the grain structure somewhat. Some grain growth is apparent adjacent to and along the line of fusion due to the effect of the high temperature which this zone was subjected to for a short time. A study of the physical qualities within this affected zone reveals a slightly higher tensile strength with an insignificant decrease in ductility.

TABLE 1 PHYSICAL TEST DATA OF OXYACETYLENE-WELDED PLATE

(Specimens stress relieved at 1200 F for 1 hour)

Specimen no.	1	2	3	4	5	6
Tensile test at reduced section, lb per sq in.	65800	57800	60000	60000	59700	62300
All-weld tensile test, 0.505 in. diam, lb per sq in.	66200	60400	60200	63900	63150	66950
Elongation in 2 in., per cent	20.5	23.5	25.5	26.0	31.0	34.0
Free-bend test, elongation, per cent	42.7	60.4	75.9	56.9	43.8	39.2
Specific gravity	7.90	7.91	7.90	7.86	7.87	7.91

Average Charpy impact test, 25.6 ft lb; 12 specimens with 10-mm-square standard keyhole.

As another check on the comparative quality of the weld metal and the base metal a hardness exploration was made. This covered the unaffected base metal, the heat-affected zone, and the weld metal across a typical gas weld after ordinary stress relieving at 1200 F. The results of this exploration are indicated in Fig. 4. It is interesting to note that there is no important increase in hardness at any point within the weld metal or the heat-affected zone as compared with the unaffected base metal. This further illustrates that in effect there is but one continuous piece of metal across the weld rather than two plates connected by a joint of widely dissimilar hardness characteristics.

With the proper method well established for gas welding to produce physical qualities in the weld metal equal to or better than those required by the A.S.M.E. Code for Class-1 work, necessary steps were then taken to qualify a number of

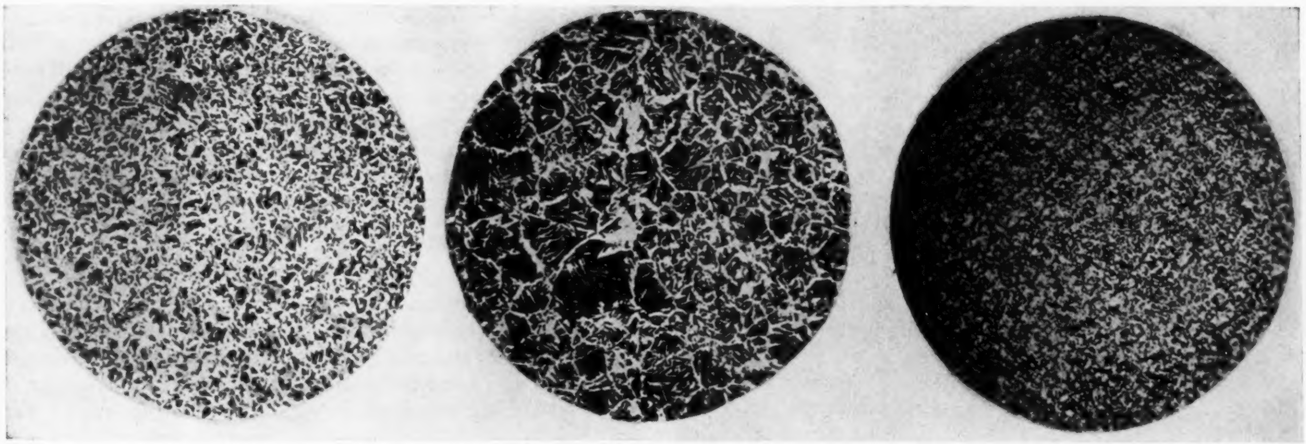

FIG. 3 MICROGRAPHS OF CROSS SECTION OF PLATE, FUSION ZONE, AND WELD METAL SHOW FREEDOM FROM DEFECTS, INCLUDING LAPS AND NONFUSION

(Etched 2 per cent Nital. ×50.)

welding operators. By following the carefully prescribed technique the welders readily qualified and demonstrated their ability to obtain welds having consistent physical properties with good ductility.

FABRICATION WORK STARTED

Shortly after qualifying our welders we received an order to fabricate a Class-1 gas-welded vessel, 5 ft 6 in. in diameter and 13 ft long, having a wall thickness of 1 in. and constructed for a working pressure of 250 lb per sq in.

The plates and heads were prepared with a double-vee type of groove and the shell blocked and rolled preparatory to welding. After rolling, the shell was carefully tack-welded approximately every 12 in. for the full length of the longitudinal seam leaving $^3/_{16}$ in. space in the clear between the edges of the vee-type groove. The first layer of weld metal was applied from the inside of the shell, every precaution being taken to see that the welders used the same procedure and technique in welding as was used on the qualification plates. Upon completion of the first layer of weld the seam was inspected and cleaned. Then the second layer of weld was applied of sufficient thickness to bring the height of the reinforcing layer $^1/_8$ in. above the surface of the plate in accordance with Code requirements. After this second layer of weld deposit had been applied on the interior of the drum, the welder had the exterior portion of the groove properly prepared by chipping to receive the first outside layer of weld metal. In chipping out and preparing the groove sufficient metal was removed to insure getting down to good, clean metal of the first layer of weld which had been applied inside.

The remainder of the groove was then welded, using the same procedure described for the inside of the shell.

PRELIMINARY INSPECTION BY X-RAY

Upon completion of this welded seam little distortion was observed, but to insure extra good roundness and alignment the shell was rerolled. It was then taken to the X-ray machine and the longitudinal seam X-rayed. At this point it was suggested by the insurance inspector that, in addition to the regular X-ray procedure, several exposures be made along the line of fusion at an angle of approximately 45 deg to the tangent line at the weld to ascertain whether the exograph would show any slight indication of nonfusion. The suggestion was carried out and there was positively not even an indication of lack of fusion. The exograph in Fig. 5 illustrates the quality of weld along this line of fusion.

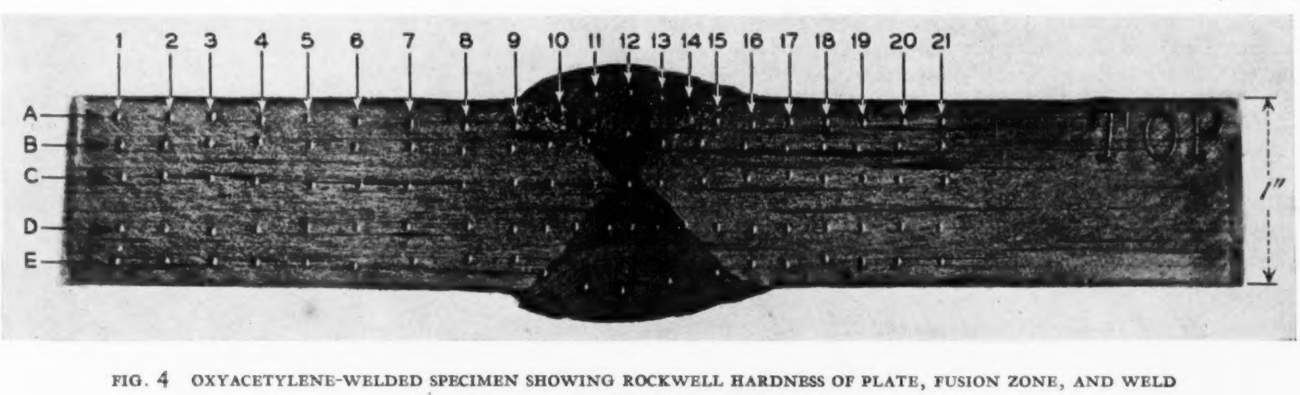

FIG. 4 OXYACETYLENE-WELDED SPECIMEN SHOWING ROCKWELL HARDNESS OF PLATE, FUSION ZONE, AND WELD

(Specimen was stress relieved at 1200 F for 1 hour.)

Row	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	63	68.5	64	68	67	71	69	69	73	79	77.5	75	75	76	75	73	75.5	76	75.5	73	79	..
B	70	71	68	69	69	72	70	68	75	74.5	80	75	80	75	79	80	79	79	75	76	..	..
C	71	73	74	72.5	86.5	76	75.5	77	73	71.5	74	85	78	79	77	76	75	76	71.5	70.5	..	..
D	74	76	74.5	71	72.5	77	75	78	80	81	82.5	85	85.5	86.5	80	77.5	73.5	74	74	72.5	74	80
E	74.5	71	74	74	77.5	79	79.5	79	82	82.5	77.5	76	77.5	71	72	70	74	77	78	74.5	..	..

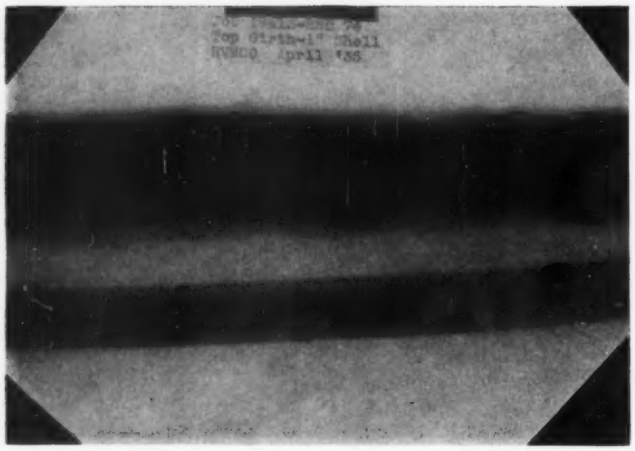

FIG. 5 EXOGRAPH SHOWING QUALITY OF WELD ALONG LINE OF FUSION

The exographs of the longitudinal seam were inspected and three small defects were questioned. These questionable flaws were located on the seam and the weld metal was chipped out. At two of these points small defects were found, one consisting of a concentrated area of porosity near the outside surface of the outer layer of weld and the other a small area of nonfusion in the center of the seam. The latter defect was undoubtedly due to failure of the operator to chip out sufficient metal from the first applied layer of weld in preparing the groove from the outside preparatory to welding. No defect was found at the third questionable point, although the weld metal was chipped out entirely through the weld. These places were then repaired, the welds X-rayed, and the exographs inspected and approved.

The heads of the vessel were then fitted to the shell, tack-welded in place, and the seams welded, using the same general procedure as in welding the longitudinal seam. We expected some distortion of the shell during the welding of the girth seams but owing either to the method of procedure or to the thickness and rigidity of the plate there was little or no distortion. Both seams were then X-rayed and the exographs inspected. Very few defects were found and those found were only of a minor nature. These were chipped out, repaired, and again X-rayed. In Fig. 6 an interesting comparison is shown in the three exographs. The top exograph is typical of the permissible defects under A.S.M.E. Code requirements. This exograph was obtained from the A.S.M.E. Boiler Code Committee. The middle exograph shows the extent of the defects found in the vessel at a few points. The third or bottom exograph shows a typical weld without defects.

The manhead and the nozzles were then fitted and welded to the vessel. The vessel was then stress relieved at 1200 F in accordance with the A.S.M.E. Code requirements. Upon completion of the stress-relieving treatment, the vessel was given the prescribed hydrostatic test. Figs. 7 and 8 show the vessel under construction.

RIGID CONTROL MAINTAINED

Since this was the first gas-welded vessel constructed to meet Class-1 requirements of the A.S.M.E. Code for Unfired Pressure Vessels, a most rigid system of inspection and control of all the details of construction, as well as the inspection of the exographs of the welded seams, was maintained at all times. Commercial standards of quality for Class-1 construction under the A.S.M.E. Code would not have required the removal and rewelding of any of the spots located. The repairs which were made were of minor extent and were made only to satisfy our own rigid requirements.

The idea has been quite prevalent among fabricators of pressure vessels that gas welding causes considerable distortion. However, this vessel showed practically no distortion. If proper care is exercised in fitting up, and if the shell is rerolled before applying the heads, there should not be a great amount of distortion, particularly when the shell thickness is $^3/_4$ in. and heavier.

COSTS CAN BE LOWERED

The cost of fabricating this vessel was considerably in excess of the cost of an equivalent vessel fabricated by electric welding. The first cost of any new process is unavoidably high owing to lack of facilities and experience. A personnel for this type of work had to be established, welding operators trained and

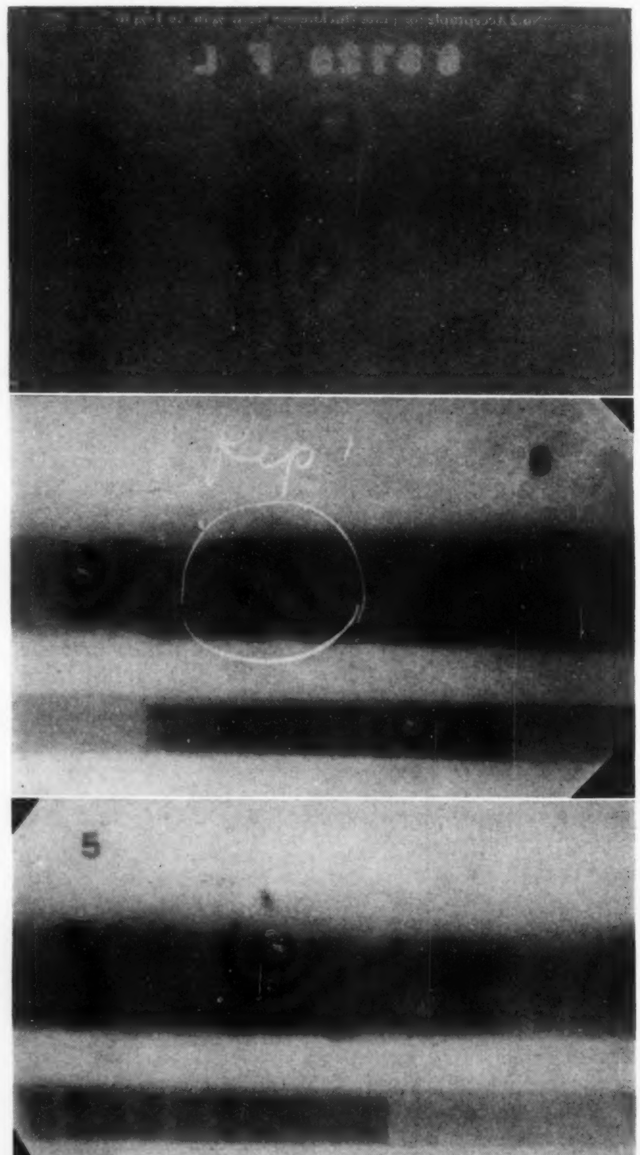

FIG. 6 COMPARATIVE EXOGRAPHS

(Top: Permissible defects under A.S.M.E. Code regulations. Middle: Type of defect found in vessel at a few points. Bottom: Typical weld without defects.)

qualified, and a thorough procedure control developed. As more gas-welded vessels are fabricated to meet Class-1 requirements, the cost will naturally be reduced.

For example, single-flame hand torches were used throughout in the welding of this vessel. This was necessary as no technique or procedure had been established and worked out for application to heavy plate of the multiflame torches or semiautomatic equipment with gravity-fed welding rods, such as is being employed on pipe and light plate. The development of such equipment for application to heavy-plate welding undoubtedly will materially reduce the cost of oxyacetylene welding. With this equipment the heat required for preparing the base metal and welding rod and for maintaining the required welding puddle can be produced and controlled by individual tips, each performing its required function. The separate control of the heat and the deposition of the welding rod in gas welding appears to offer a definite advantage over electric welding where this flexibility of control is not present. This should be particularly important in future developments leading toward the more rapid deposition of weld metal. Full mechanization of the application of the oxyacetylene process also seems to have some very definite possibilities.

There are two other factors which seem to favor further developments of oxyacetylene welding for Class-1 construction, now that it has been well demonstrated that the physical requirements may be readily complied with.

In the gas welding of Class-1 pressure vessels the exographs will and should reveal welds that are practically flawless and chipping out of defects and repairing of welds should be largely eliminated. Repairing of welded seams during the course of construction is a costly procedure and its elimination would materially reduce the cost of welded fabrication.

Because of the lower temperature gradient established between the base metal and weld metal in gas welding, residual stresses are not as highly concentrated as in electric welding. Although Class-1 vessels are stress relieved to relieve such stress concentration, this factor may at times require special procedure for electric-weld construction which would not be required were gas welding employed.

Because this was the first Class-1 gas-welded vessel to be X-rayed and tested by our company in accordance with the A.S.M.E. Code, no definite speeds had been developed in our technique so as to place the drum on power rollers in order to revolve it during welding. Therefore, we placed it on ordinary rollers and rolled it by hand to position it for the welding operator while he welded the girth seams.

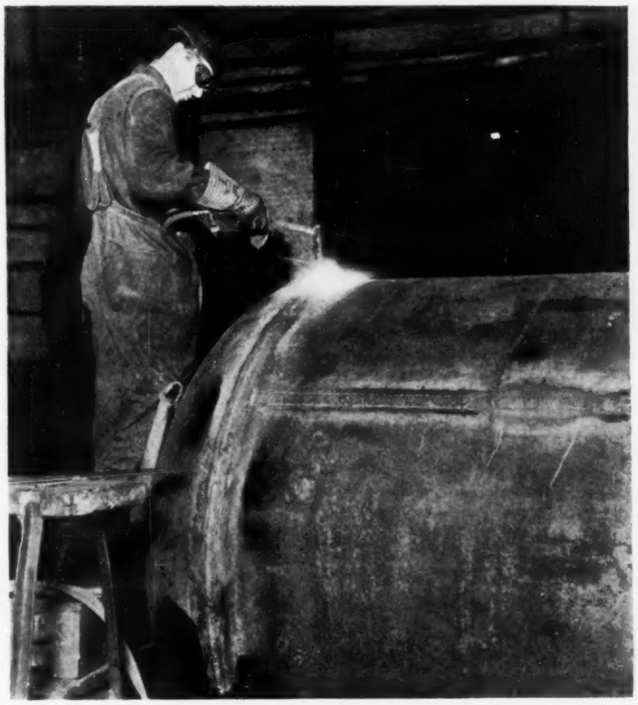

FIG. 8 OPERATOR WELDING THE OUTSIDE GIRTH SEAM

We have since conducted some experimental work on speeds for gas welding with the work placed on mechanically operated rollers and predict that important time saving will be made in welding girth seams of vessels in the future.

BENEFITS OF ENVELOPE FLAME

Since it has been learned that practically the same protecting atmosphere surrounding the molten puddle of weld metal can be obtained with the proper gas flame as is now obtained with the correct coating on an electrode in electric-arc welding, a new field of development for improving gas-welding technique appears feasible. With the knowledge gained from the investigation of atmospheres developed by gas flames, it seems that in the near future an automatic welding machine will be developed which will combine and make use of the good qualities found in both the gas and electric processes. With a combination of these two processes, it is entirely feasible that an automatic machine can be built to use a coil of bare-wire electrode which will make the welding operation continuous while the necessary atmosphere, so essential to good-quality welding, will be secured through the application of gases from some combination of oxygen and acetylene or other available gases. When such a machine is perfected welding costs will be greatly reduced and an important forward step made in uniting metals for industrial purposes.

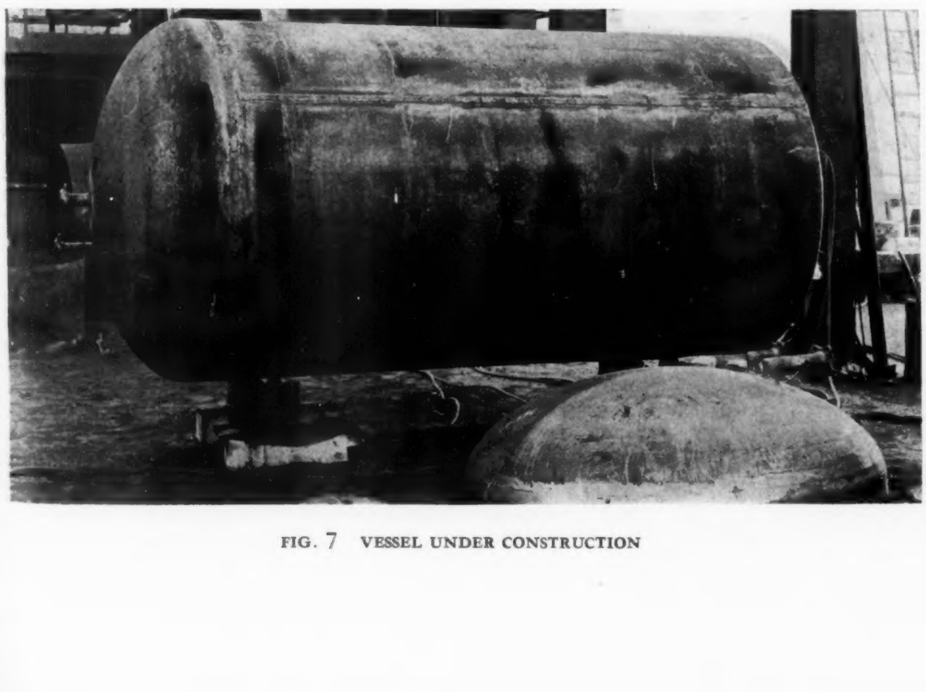

FIG. 7 VESSEL UNDER CONSTRUCTION

WORK *and* FATIGUE

The Maintenance of Physiological Efficiency in Industry

By H. W. HAGGARD

DEPARTMENT OF APPLIED PHYSIOLOGY, YALE UNIVERSITY

WORDS may outlive their usefulness; they may in time cease even to express their intended meaning and give instead a false impression. Such I believe to be the case with two words widely used in industry, but derived from physiology. They are the words "work" and "fatigue." It is my intention here first to show some of the physiological errors into which the use of these two words may lead, and second, to discuss one of the numerous causes of diminished productivity often falsely attributed to fatigue.

The terms "work" and "rest" are quite erroneously taken to express entirely opposite conditions. In reality they are not opposite; they are the same conditions varying only in degree. The body, as long as it is alive, is never at rest. In the physiological sense work is always being performed. Even in the most extreme muscular relaxation, the muscles are active and the vital functions of all the organs are carried on continuously.

Often the energy directly expended for the performance of light manual tasks is considerably less than that expended by the body during the state of so-called complete rest. Thus a man of average size sitting at rest—performing no task at all—expends energy at the rate of approximately 100 calories per hour. The same man, performing an occupation such as typewriting, increases the expenditure to only about 140 calories per hour; the energy expended directly on the task is thus only 40 per cent of that expended while sitting at rest. By walking at a moderate pace, or by carrying out such occupations as carpentry or painting, the expenditure is raised to about 200 calories per hour, i.e., only double that at rest. In strenuous exertion such as digging or chopping the expenditure may go up to five or six times that of resting, and in athletic activities to 10, 20, or even 40 times that of resting.

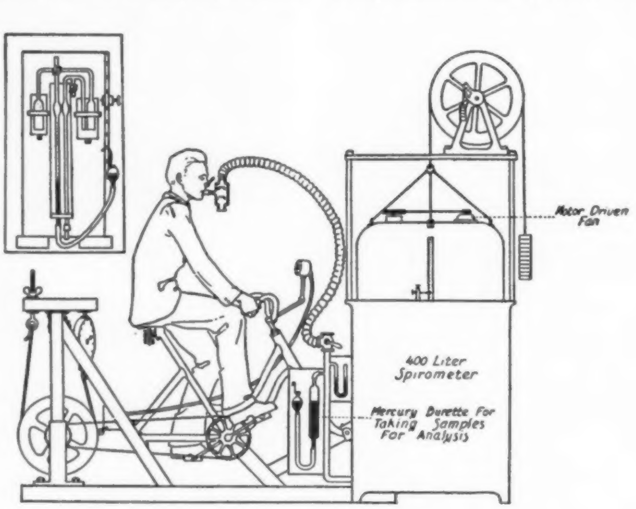

FIG. 1 APPARATUS USED FOR DETERMINING RATE OF ENERGY EXPENDITURE AND MUSCULAR EFFICIENCY
(The insert shows a gas analyzer.)

I do not question the development of fatigue in the true sense of the word in these more strenuous exertions. Fatigue is a demonstrable physiological condition arising from the fact that energy is expended by the muscles in excess of the rate of the reparative processes. This fatigue shows as weariness, diminished productivity, and finally, inability to do further work. The condition is relieved by rest.

It is difficult for me to believe, however, that an analagous condition develops when the task is of such a nature as to demand only a doubling or a tripling of the resting rate of energy expenditure. And the vast majority of all industrial occupations fall within this group.

Yet many men carrying out such occupations show progressively diminishing production during the day, and generally at the end of the day are tired. By an extension of the conception of the well-known process of fatigue developing from violent exertion, this diminished production and feeling of tiredness have also been classed as fatigue.

I do not believe they are fatigue. I am strongly of the opinion that impairment of productivity can be caused by many factors that do not, as does true fatigue, arise out of the work performed, but rather out of the conditions—mainly psychological—under which the worker performs the task. In this regard I should put down as the two most potent causes of diminished productivity, ill health and poor selection in supervisors.

But these matters concern general levels of production and are aside from the problem with which I am concerned—that of progressively diminishing production during the course of the day. Many of the psychological conditions lower this level; but I am concerned with a condition far more closely resembling, in general appearance, the typically progressive development of fatigue. And I wish to show that it is not fatigue.

To this end I turn first to a study that we have made of muscular efficiency. Human muscular efficiency, recorded as net thermal efficiency, has been studied by many investigators to determine approximate values for different sets of muscles and to determine changes from day to day under various conditions of work and diet. But little or no attention has been given to the possibility that efficiency may fluctuate within the hours of a single day. Indeed, it has largely been the practice to confine determinations of efficiency to the so-called post-nutritive state (before breakfast in the morning), in order to make comparisons under conditions free from possible disturbance arising from digestion. And yet change in efficiency developing during the course of the day would have an important bearing upon the practical problems of industry and indeed of all daily activities. If efficiency diminishes during the working day, even for manual occupations too light

Contributed by the Management Division and presented at a symposium on Effect of Technological Changes on Human Relations at the Annual Meeting, New York, N. Y., Dec. 2–6, 1935, of The American Society of Mechanical Engineers.

TABLE 1 MUSCULAR EFFICIENCY OF A SUBJECT EATING THREE MEALS A DAY

(Subject, male, age 25)

		Total energy expenditure in cal per min			
Time a.m.	Remarks	Sitting at rest	Doing work	Energy expended upon work	Muscular efficiency, per cent
6:30		1.43	8.47	7.03	19.5
7:00	Meal	...	...	...	...
8:00		1.60	6.72	5.12	27.0
9:00		1.56	6.83	5.27	26.2
10:00		1.50	6.98	5.48	25.2
11:00		1.48	7.48	6.00	23.0
12:00		1.49	8.01	6.52	21.2
p.m.					
12:15	Meal	...	...	...	...
1:00		1.62	6.93	5.31	26.0
2:00		1.59	6.97	52.5	26.3
3:00		1.54	7.00	5.46	25.5
4:00		1.49	7.37	5.88	23.5
5:00		1.46	7.93	6.47	21.4
6:00		1.47	8.10	6.63	20.8

to produce true fatigue—and we have found that it does—the task performed will seem progressively harder; the energy expended will be greater. The worker will have the sensation that the task is becoming more difficult. Unless a deliberate and conscious effort is made to maintain a uniform rate, production will diminish. A rise in muscular efficiency will act in the opposite direction; the work will be easier.

In the study which I am reporting the muscular efficiency was determined at hourly intervals throughout the day on a number of subjects. The apparatus which was used consisted of a bicycle ergometer and suitable metabolic apparatus as shown in Fig. 1.[1]

The subjects sat at rest throughout the day except for five minutes in each hour when they rode the bicycle which was so adjusted as to require external work at the rate of 1.38 calories per minute. Suitable consideration was given to the matter of oxygen debt and full recovery for each determination. The net muscular efficiency at the hourly intervals was calculated from the ratio between the external work developed and the total energy devoted by the subject to performing the work. Table 1[1] shows the results of a typical experiment of this kind carried out for one subject over a period of $11^1/_2$ hours.

[1] All illustrations and tables used in this paper are taken from "Diet and Physical Efficiency," by H. W. Haggard and L. A. Greenberg, Yale University Press.

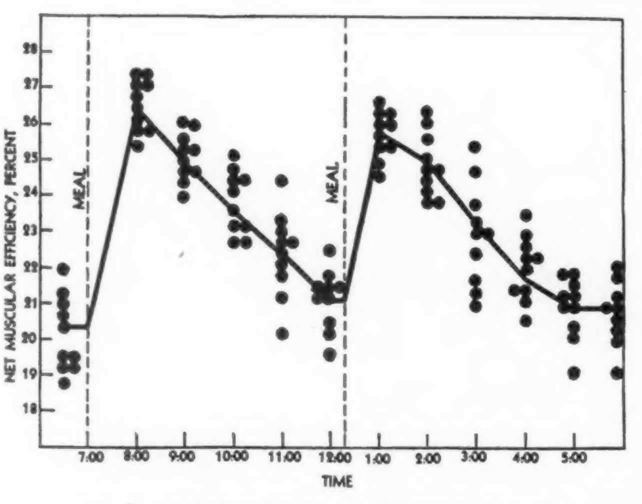

FIG. 2 COURSE OF MUSCULAR EFFICIENCY IN TEN SUBJECTS EATING THREE MEALS A DAY

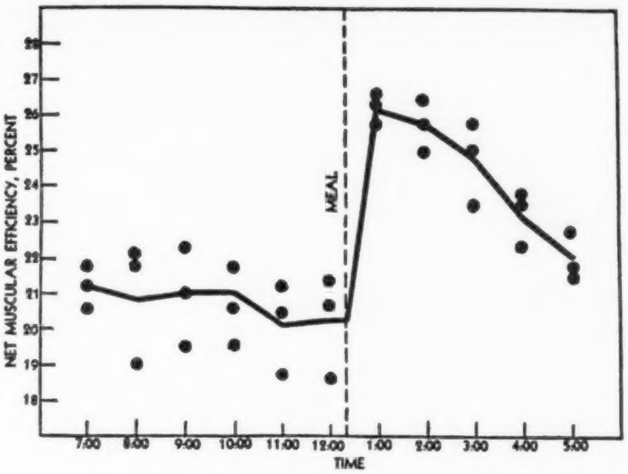

FIG. 3 COURSE OF MUSCULAR EFFICIENCY IN THREE SUBJECTS OMITTING BREAKFAST

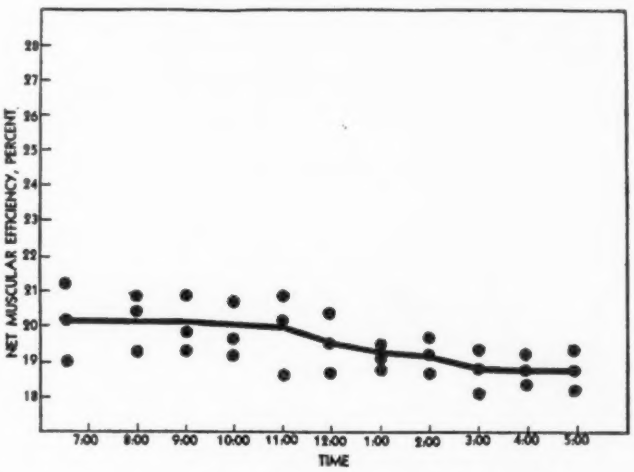

FIG. 4 COURSE OF MUSCULAR EFFICIENCY IN THREE SUBJECTS FASTING

It will be noted that the muscular efficiency before breakfast was 19.5 per cent and that one hour after breakfast it had risen to 27.0 per cent. Thereafter it fell progressively; four hours after breakfast it had reached 21.2 per cent. The sequence in the afternoon was similar to that of the morning; the efficiency rose to 26.0 per cent after the noon meal and fell to 20.8 just prior to the evening meal.

Fig. 2 shows the course of muscular efficiency in ten subjects eating three meals a day.

Fig. 3 shows the course of muscular efficiency in three subjects omitting breakfast.

Fig. 4 shows the course of muscular efficiency in three subjects during fasting.

In 1920 Krogh and Lindhart showed that men kept on prolonged diets high in fat have on the average a muscular efficiency 11 per cent lower than when they were kept on a prolonged diet high in carbohydrate. This work has been abundantly confirmed.

But I was the first to suggest that comparable changes in efficiency, as fluctuations from hour to hour, took place during the day in the individual on a mixed diet. It is a well-known fact that from two to three hours following meals of a mixed

TABLE 2 AVERAGE PROPORTION OF FAT AND CARBOHYDRATE BURNED IN SIX SUBJECTS EATING THREE MEALS A DAY, INDICATED BY THE RESPIRATORY QUOTIENT, R.Q.

Time a.m.	R.Q.	Blood sugar, per cent	Proportion of carbohydrate and fat entering into combustion: Carbohydrate, per cent	Fat, per cent
Pre-breakfast	0.79	0.096	28.3	71.7
9:00	0.92	0.154	72.7	27.3
10:00	0.87	0.111	55.6	44.4
11:00	0.84	0.092	45.4	54.6
12:00	0.78	0.092	24.9	75.1
p.m.				
1:00	0.91	0.149	69.3	30.7
2:00	0.86	0.116	52.2	47.8
3:00	0.86	0.108	52.2	47.8
4:00	0.82	0.090	38.6	61.4
5:00	0.79	0.091	28.3	71.7
6:00	0.79	0.101	28.3	71.7

diet a high proportion of sugar is burned as the source of energy and thereafter a high proportion of fat.

Table 2 shows the average proportion of fat and carbohydrate burned in six subjects eating three meals a day.

On the basis of preliminary observations, I was led in 1923 to make the statement that a falling off of production and a feeling of fatigue, developing late in the morning and late in

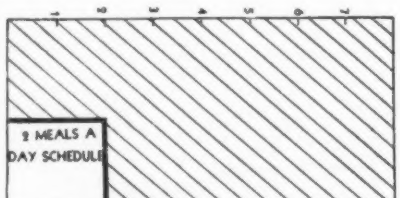

FIG. 5 HOURS DURING THE PERIOD OF THE WORKING DAY IN WHICH RESPIRATORY QUOTIENT (R.Q.) REMAINS ABOVE THE BEFORE-BREAKFAST LEVEL ON VARIOUS MEAL SCHEDULES

the afternoon, could probably be relieved by taking food. I also suggested at that time the administration of sugar to athletes prior to contests. It was not until the period 1930 to 1934, however, that I was able to follow this work through to its completion.

Our laboratory studies involved a long series of hourly determinations of the muscular efficiency, of blood sugar, and of the respiratory quotient.[2] The last value, which, under

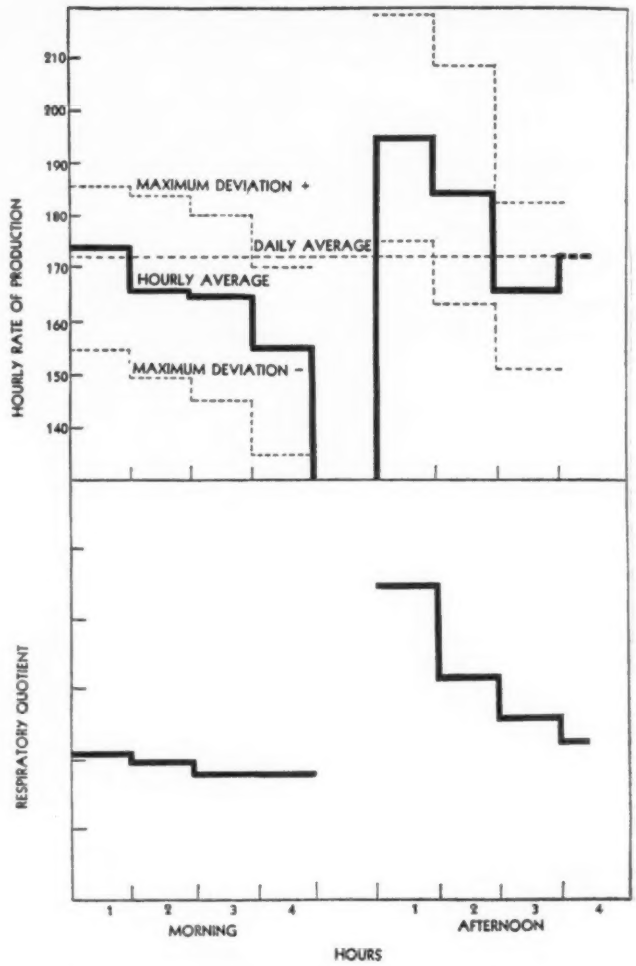

FIG. 6 AVERAGE HOURLY RATE OF PRODUCTION AND AVERAGE HOURLY LEVEL OF RESPIRATORY QUOTIENT OF OPERATORS EATING TWO MEALS A DAY

carefully controlled conditions is an indication of the nature of the fuel burned in the body, was determined at hourly intervals throughout the day on 213 subjects.

The conclusions reached are summarized in Fig. 5 which shows the hours during the working day in which the respiratory quotient, and hence muscular efficiency, is above the before-breakfast level on various meal schedules.

The next step was to carry the work into the factory. Walter H. Norton and his associates of the United States Rubber Products, of Naugatuck, Conn., extended to us the facilities of their plant.

Our work there was carried out on small groups of operators doing piece work and paid on the task and bonus system.

[2] The respiratory quotient, R.Q., is the ratio between the volume of carbon dioxide produced and the oxygen consumed in metabolism. The body normally may burn either fat or carbohydrate in vital combustion but usually consumes varying proportions of each simultaneously. The amount of oxygen used and carbon dioxide produced in any case is based on simple chemical reactions. When carbohydrate is burned the volume of carbon dioxide produced is equal to the oxygen consumed and the R.Q. is 1. In the combustion of fat the R.Q. is 0.7.

By chemical analysis of the expired air the ratio of oxygen consumption to carbon-dioxide liberation may be determined. The respiratory quotient thus obtained indicates at once which of the fuels is being burned. It also indicates the proportion of fat and carbohydrate entering into combustion when these substances are burned simultaneously. Thus, if equal quantities of carbohydrate and fat are being burned the R.Q. will be neither 1.0 nor 0.7, but a value midway between the two, namely, 0.85. Higher values indicate a greater proportion of carbohydrate; lower ones, a greater proportion of fat.

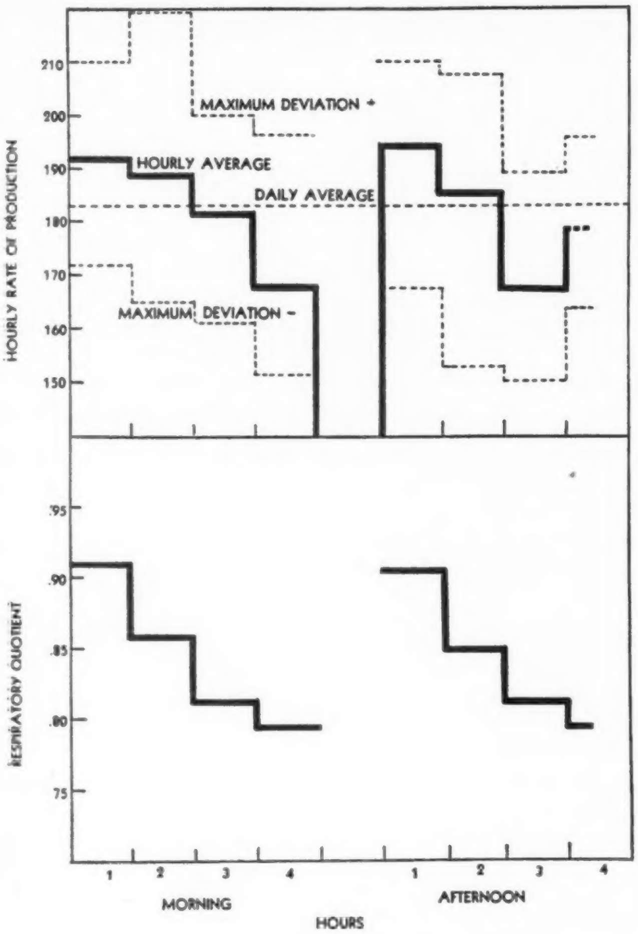

FIG. 7 AVERAGE HOURLY RATE OF PRODUCTION AND AVERAGE HOURLY LEVEL OF RESPIRATORY QUOTIENT OF OPERATORS EATING THREE MEALS A DAY

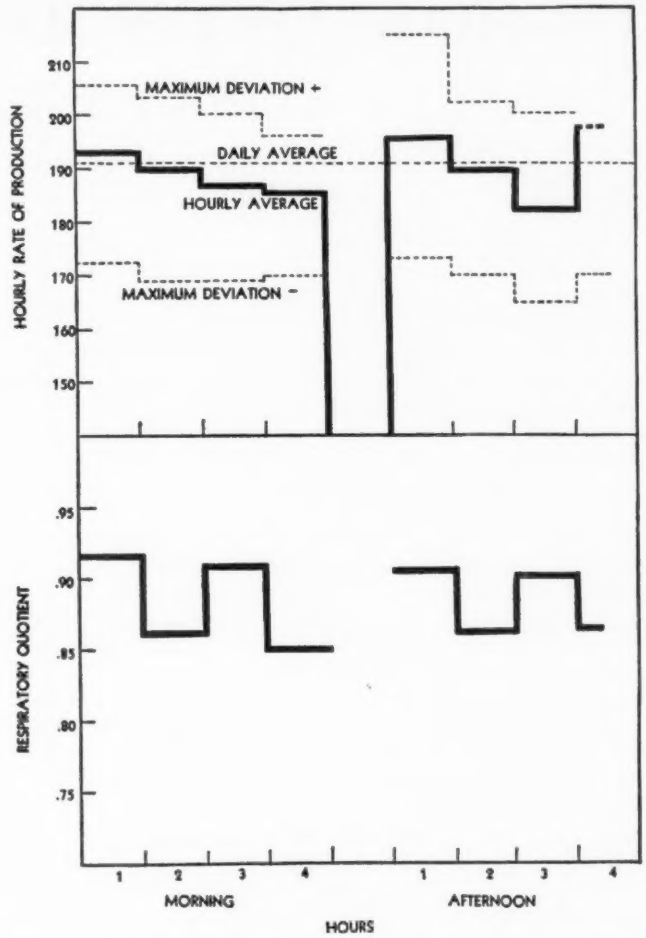

FIG. 8 AVERAGE HOURLY RATE OF PRODUCTION AND AVERAGE HOURLY LEVEL OF RESPIRATORY QUOTIENT OF OPERATORS EATING FIVE MEALS A DAY

Each operator of each group was timed by an observer from behind a "blind" and watched over several weeks before actual determinations were made.

Fig. 6 shows the average hourly production of operators eating two meals a day and also the respiratory quotients of operators eating two meals a day.

Fig. 7 shows similar data for operators eating three meals a day.

Fig. 8 shows similar data for operators eating five meals a day.

The two extra meals were given mid-morning and mid-afternoon and consisted of milk and cake, the latter in gredient being selected at the request of the operators.

Finally, Table 3 shows a comparison between the mean hourly output of 20 operators who were eating three meals a day and of 20 operators who were variously eating three and five meals a day.

It will be observed that during the periods when the two extra meals were given the production of the 20 operators of the experimental group rose approximately 10 per cent. Moreover, they voluntarily commented on the fact that on the days the extra meals were given they felt less tired than on the days when they ate their customary three meals and that in spite of the fact that they were actually doing more work.

It will be noted that the benefit of the additional meals is not carried over to the following week. The rate of production during the period in which three meals were eaten immediately following the period in which five were eaten, showed no increase over the expected rate.

TABLE 3 PRODUCTION OF OPERATORS EATING THREE AND FIVE MEALS A DAY

Control group 20 operators eating 3 meals a day	—Mean hourly production for period of 2 weeks— Days 1	2	3	4	5	6	7	8	9	10	Average of 2 weeks
1st period of 2 weeks................	179	186	184	180	183	174	184	187	186	188	183
2nd period of 2 weeks................	177	184	183	179	186	180	186	189	187	187	184
3rd period of 2 weeks................	180	180	185	187	186	179	182	187	187	181	183
4th period of 2 weeks................	179	184	184	186	184	180	183	188	189	186	184
5th period of 2 weeks................	181	184	187	184	183	180	181	188	189	186	184
Experimental group 20 operators											
1st period of 2 weeks eating 3 meals a day	169	174	178	176	178	172	178	178	176	177	175
2nd period of 2 weeks eating 5 meals a day	189	192	192	193	193	188	189	196	196	195	192
3d period of 2 weeks eating 3 meals a day	171	175	177	177	176	173	176	178	178	179	176
4th period of 2 weeks eating 5 meals a day	191	194	193	191	191	189	196	197	195	194	194
5th period of 2 weeks eating 3 meals a day	173	175	178	178	176	168	173	177	176	173	176

HOW TECHNOLOGICAL CHANGES AFFECT EMPLOYEES

By MORRIS S. VITELES

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CERTAIN economists and psychologists have become much disturbed about the possible effect of technological changes in dulling the minds and disturbing the emotional adjustment of employees by forcing them into tasks involving highly specialized repetitive activity.

The results of systematic, scientific study of specialized repetitive work show that much of the blame leveled against it is wrongly directed. Machine work, intense work, repetitive work at an imposed speed and rhythm can be challenging and absorbing, to some workers at least. There seems to be no universal, deep-seated conflict with an instinct of workmanship. As a matter of fact, there are many who find routine work desirable, who like automatized tasks that leave the mind free for other pleasurable activities. There are others, apparently a smaller number, who rebel against uniform, specialized work, but even here adaptation is not so difficult as is suggested by the protagonists of the "creative" instinct.

Perhaps the most encouraging aspect of these studies is their failure to confirm the point of view that the human mind is dulled, emotional maladjustment intensified, and broader social participation hindered by repetitive work. In this the findings of experimental investigation coincide with what is shown by a review of the history of work. Throughout the ages a large proportion of workers have been accustomed to some form of repetitive work. The shorter working day, the higher standards of living, the facilities for employee recreation and education made available by progressive industrial firms and public agencies, combine to give the worker an opportunity for self-expression outside of working hours beyond the scope of anything that existed in earlier ages. The problem is partly one for the school to solve. Its solution may involve an attempt to substitute more productive and creative experiences for the automobile ride, the baseball game, the movies, the radio which at present seem to occupy the spare time and mind of the American worker. And, if the majority continues to find adequate satisfaction in these, perhaps this in itself is evidence that creative experience is something which today, as in the past, is craved by only a few selected spirits.

INDUSTRY HAS PRESSING DEMANDS FOR SKILLED WORKERS

Among the accusations leveled at modern industry is that it has decreased the demand for skill in work. The specialized jobs in the automobile-assembly line are repeatedly cited as proof that workers have been reduced to the status of machine feeders and machine tenders, deprived of initiative and responsibility on tasks which require practically nothing in the way of skilled accomplishment and training for their performance.

A review of the history of work and detailed studies of occupational trends show that industry is still faced with the problem of developing skill in its employees. Today there is a tremendous demand for both technical skill and technical knowledge in the construction, maintenance, repair, and adjustment of the marvellously intricate and deft machines that perform much of the handwork formerly done by man. The "iron man" has created for his own making a need for workmanship and special knowledge unknown to the ages of simple primitive tools. Moreover, the fundamental basis of this skill and knowledge is not tradition—a blind continuation of processes established by long usage—but the development of new skills involved in the production of new machines, new operations, and new processes.

There is still the need for systematic training on the job. That this is the case is supported by facts uncovered in recent studies of occupational trends within specific occupations. Such studies show that skill—more particularly manual skill—still has an extremely important place in modern industry. Of course, there are other industries in which the demand for skill has declined at a greater rate than in those already mentioned, but in many the changes are more gradual than would have been expected. In general, figures for industries which have been studied by the Personnel Research Federation and other agencies hold little solace for the technocrats whose star blazed so brightly for so short a time. The fact is that in spite of the machines and horsepowers of energy available to the worker, skill is still needed in industry. Its development in the worker, through systematic training, is an important function of industrial management today.

However, although skill is important, there are industries in which automatization is taking place at a rapid rate and in which some adjustments in the training of employees are required. There is no doubt, that the outstanding demand in many modern plants is that for flexibility and mobility on the part of its workers. From the viewpoint of preparing employees for work "today factory workers should be taught not one trade but the basic operations of industrial production as a whole. The exact manner of handling a particular machine is less important to know now than formerly, when jobs were less rigidly defined and less quickly learned. A production worker would benefit more from training in *dexterity* and in *bimanufiability* than from detailed mechanical knowledge."

From the viewpoint of the vocational school and of industry this means, of course, that it is necessary to conduct training so as to develop in the individual a set of fundamental skills that can be used on many jobs, thereby providing for quick adaptation to rapidly changing forms of work.

Industry, for example, can facilitate transfer within the organization by training its experienced workers—particularly the older ones—in the principles and practices of the jobs to which each can be most easily transferred in case of replacement of his job by machines. The application of this policy may mean, for example, that meter readers in an electric and gas utility will be trained not only in the approved practices of meter reading, but will also receive detailed instruction in the work of the bill collector, the job to which meter reading is related most closely on the organization chart. Employees

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in traditional coke gas-making plants will become acquainted with the reformed oil process, in preparation for the day when a shift in operating practice may be found necessary. That this is a practicable program has been demonstrated in the work of a number of progressive organizations, such as the Philadelphia Electric Company, which have formulated such training plans as an aid in transferring to available jobs employees who would otherwise be dropped from the payroll.

RELATIONSHIP BETWEEN UNEMPLOYMENT AND MORALE

One important effect on the employee is associated with the influence of technological change in increasing unemployment. There is no question that unemployment, particularly continued unemployment, is a fertile source of maladjustment. Few experiences can be more disturbing to the mental health of the worker than the haunting fear of losing his job under which so many employed workers are laboring today, or the discouragement, the hopelessness, the sense of futility awakened by the inability of the individual to sell his services.

A recent study by Hall, of the Personnel Research Federation, gives evidence of the relationship between unemployment and morale. In this a group of unemployed and a group of employed engineers were compared with regard to their occupational morale, their attitudes toward employers as a class, and their attitudes toward religion, after the two groups had been matched with respect to age, salary (on the last job of unemployed men), nativity, education, religion, state licensing, marital status, and occupation. Seventy-five per cent of the unemployed men had poorer morale than the average employed men, and 68 per cent were more antagonistic toward employers as a class. The net effect of the experience of unemployment on attitude toward religion was found to be small.

The morale of destitute men who had been given "work relief" or "made work" was found to be definitely better than the morale of men who, although similarly destitute, had not received such help. The morale of employed men who anticipated losing their jobs almost any time was as low as that of unemployed men who were in no particular need. In general, the results support the opinion that the grave consequences of unemployment reach beyond material discomfort, beyond the disintegration of skill and health, to undermine a man's attitude toward his fellows and toward social controls.

The Place of SKILL *in* INDUSTRY

By LILLIAN M. GILBRETH

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SCIENTIFIC management has, since its beginning, stressed the importance of skill. A reading of the classics in this field makes this clear. By 1912, L. P. Alford and his colleagues, in writing the report of the Subcommittee on Administration, of The American Society of Mechanical Engineers, were saying, "It appears, however, that another principle is the basic one in the rise of industry. It is the transference of skill." In 1922 when Mr. Alford wrote "Ten Years Progress in Management," he reiterated the findings of the 1912 report, that the new element in management was, "the mental attitude that consciously applies the transference of skill to all the activities of industry." He also stated that "appreciation of the importance of the human factor in industry and attempts at its study from the fact basis have been the most striking management development." A careful review of the reports of the A.S.M.E. Management Division since that time and of the writings of those members who represent its leaders in this field shows that there has been no change in the belief that the study of the transference of skill, and hence of skill itself, is of paramount importance in the development of the science of management and the progress of industry.

Various questions have arisen, that should be answered in a discussion of the place of skill in industry. For example:

1 Is The American Society of Mechanical Engineers an appropriate group to conduct such a discussion?

2 How is skill defined in general and by this group?

3 What are the problems involved in conserving, using, and developing skill in industry?

4 How can these problems best be solved?

1 The American Society of Mechanical Engineers is a fitting group to discuss the place of skill in industry, for the Society concerns itself with the development of human nature as well as of nature. It does not, of course, possess or pre-empt the field of management, but it has a large and active professional division, the Management Division, that concerns itself with problems that include the handling of men as well as materials and machines. A review of the papers presented to this division and of the discussions on them proves that the interest in the human element grows continually.

2 Skill has not as yet been adequately defined in any report of The American Society of Mechanical Engineers. It is difficult to define skill, and perhaps no suggested definition would meet with universal approval at this time. It is proposed that we take the definition, "Skill is dexterity, plus knowledge, which can adapt itself to changing situations and is capable of improvement." This definition is in conformity with definitions of the words used in the Century Dictionary. It concurs with the usage of British and American psychologists.

3 The problems in developing skill in industry concern

(*a*) Recognizing skill—first step in conservation
(*b*) Recording skill—second step in conservation
(*c*) Transferring skill—conservation and development
  (1) From man to man—increase, this is teaching
  (2) From man to machine—possible decrease
(*d*) Developing skill—conservation and increase
(*e*) Using skill—fatigue study, motion study, motivation.

4 Industry is attempting to recognize skill through job analyses, job classifications, and studies of earnings in their relationship to kinds of work done and quantity and quality of output. The relationship between skill and specialization is being investigated by economists and sociologists. The various studies of the British Industrial Health Research Board, published by His Majesty's Stationery office, London

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assist in furnishing technics for recognizing skill by presenting tests of dexterity, included by the board as a part of skill.

CLASSIFYING AND RECORDING SKILL

In order to stimulate interest in recognizing and discussing skill it has been proposed to supplement the more technical classifications by a simple one, which divides them into skill in handling materials, in handling machines, in handling money, in handling memoranda (i.e., the so-called "paper work"), and in handling men. This classification has been tested on job specifications in a large retail establishment and has been found a help in selection and placement, in training, and in promotion. This last-named use is especially important, as it avoids the failure to recognize that the new job may call for other skills than did the old, and so a new need for training.

Among the available ways to record skill are the film, preferably the micromotion film, and the cyclegraph. The latter presents records in three dimensions and includes time. The records of skilled activity (in work and leisure) show patterns, grace, rhythm, acceleration, and deceleration that indicate control and balance. The results of the activity, as presented in the films, have that high-grade quality that makes inspection a record rather than a test. The results, as presented in the chronocyclegraph, indicate the effect of habit and its lapses.

Recording skill makes it available for teaching but it does not necessarily keep it in active use. On the other hand it may be passed on without being recorded. But change is likely, and the state of the art at any given time should be provided for by records. These also make transfer easier.

TRANSFERRING SKILL TO MEN AND TO MACHINES

Skill may be transferred to men or to machines. Adequate records can provide for visual education, oral education, and even motor education. They can also indicate where attempts at transfer to machines should be abandoned, either because the activity is not transferable or because the human element will profit if the activity be not transferred. Transfer of skill from man to man should result in its increase unless those who transfer it abandon its use as soon as they have handed it on, or those who have received it fail to use it. The science of education takes over the task of studying this transfer in the learning process, in the advantages of pleasurable learning, and in tests of adequacy. Habit establishment and the part played by the threshold of consciousness are receiving increasing attention.

The early management engineers, as their thinking is reflected in the Progress Reports of The American Society of Mechanical Engineers, seem to have held that even the higher ranges of skill can be transferred from man to machine, and to have feared lest the results of such transfer should be dangerous to the man's development. The study of the records of skilled activity, which resulted in including adaptability as a factor of skill, proved that while the findings of knowledge and dexterity may be transferred from man to machine, adaptability may not. This has affected machine-man relationships. Needs for adaptability, as they affect the machine, have been eliminated by careful inspection of the materials used, the tools used, and the delays of all sorts.

Fortunately, the growing conviction that the man, not the machine, should be the center of all machine activities is leading to better design of machines. These will actually enable the man to exercise more skill as they eliminate the drudgery from work and act as an extension of the worker's potentiality and of his personality. They will make it possible, as do his tools, for him to do things that he could never do without them. The real danger is not that men will transfer their skill to machines, but that they will believe that this is possible and will stop developing their skill when they have handed over the repetitive work that requires no adaptability and creative activity to the machine.

Skill may thus be developed as it is transferred from man to man; and the number of people possessing it is increased at the same time that the product of the skill is increased and improved. We see this as we study the best in machine use and in machine product. As a result of machines, many and valuable skills have been developed. We are only beginning to realize their importance and the great beauty of them and of the product of the finest machines used by the most skilled machinists. The Proceedings of The Sixth International Management Congress at London in 1935 and the discussions of the many papers presented there prove that there is increasing interest in the results of mechanization as they affect esthetic development as well as economic conditions and industrial problems. There is much to be done in this field.

Industry is weakest in its use of skill. Perhaps this is not its fault, but the engineering profession has the responsibility of bringing the facts to light. Proper use demands the elimination of unnecessary fatigue and provision for recovery from that which is necessary. Fatigue not only makes the worker less capable of doing skilled work but affects the product appreciably. It increases safety hazards. Right work methods, the result of motionmindedness, performed at the appropriate speed, lead to safety of the worker and to the uniformity of the product, so desired by consumer and so satisfying to producer.

Most serious of all is the failure to consider the influence of inadequate motivation, the lack of the incentive. Engineers have feared that the events of the last years, such as failure to develop skilled workers, unemployment, and code restrictions, would seriously affect skill. Findings of careful investigations by the National Industrial Conference Board in 1935 as to what has happened in the metal-manufacturing industries confirm these fears. And worse than that, we have reason to fear that the conditions presented exist in many other industries. It is clear that we must at once try to remedy the conditions that reduce skill and to create a supply of skill to replace what we have lost or destroyed.

This means not only reestablishing the means of recording, transferring, developing, and using skill, but also finding new means. A fundamental belief in the importance of skill must be established not only in industry but everywhere. Unselfishness is, of course, prerequisite to success in building a constructive program for skill development, as it is prerequisite to the changes in economic thinking and in educational procedure that will be necessary. Schools and colleges must join with industry in finding and fostering aptitudes. The rigid training of the engineer, which he is accustomed to apply to fact finding, should also be applied to interpretation of the facts. Underlying causes should always be sought, for they are essential to an understanding of the facts.

There is probably no one who seriously wishes skill to decrease. It is too closely allied with satisfactions, and these are essential to the good and happy life. We are only now beginning to analyze satisfactions and to discover that, tangible and intangible alike, they are closely related to variety, amount, and adequate use of skill. This is no time for wishful thinking. We must look at the end we desire. It is a race of men who will be able to discriminate, to know the good and the beautiful, to choose it, and to possess it. It is an age that should use the machine to help men to these things and that should produce enough things that are the result of skill so that every one can have what he needs and bring what he has a little nearer to what he wants.

HUMAN PROBLEMS CREATED *by* LABOR-SAVING MACHINERY

By ELIZABETH FAULKNER BAKER

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I BELIEVE we have entered a new stage in our attack upon the human problems presented by labor-saving machinery. And this because we know a great deal more about the nature of these problems than even a half dozen years ago. We know that in the past, although the introduction of machines brought suffering and resentment from workers, it was hailed as progress by both industry and government. Whereas, since the world war we have absorbed inventions with such rapidity and mechanized production processes at such an accelerated pace that progress is challenged by an acute and threatening situation. What has been termed technological unemployment has now become the concern of both industry and government.

However, after analyzing the phenomenon we are on the whole encouraged rather than discouraged. For it is clear that the machine is not by nature a diabolical enemy of the worker, but a means of raising indefinitely his plane of living.

Because of our fuller understanding of the problems of technical change, we have begun to approach them from a different angle and in a different spirit. It is not the machine that causes human misery but our failure to absorb the machine, and the power that drives it, into our social and economic processes. We are in an age of technology but we have failed to revise our cultural patterns to embrace technology. In so far as labor-saving machines are installed when plant and society are unprepared to cope with the human problems they create, that far these machines will surely continue to saddle us. The fault, however, lies largely in our technoculture; and the unemployment that follows is, as I see it, technocultural unemployment.

There is evidence of improvement in our American technoculture. For example, the Congress in August, 1935, passed a Federal Security Act. Other visible forward steps taken by the federal government, whether or not they are momentarily declared unconstitutional, are the Guffey Coal Act, the Wagner Labor Relations Act, the creation of the Security Exchange Commission, the trade pact with Canada that looks toward a lowering of international tariffs, and the wider powers given to the Federal Reserve Board toward better functioning of banks in an economy so altered that price-cost adjustments are no longer automatic.

Within the plant also, it is now better realized than before that the introduction of labor-saving machines on the present scale is a disrupting force of major proportions that makes imperative demands. Like a critical operation upon a human body, if the step is not scientifically prepared for in advance, expertly executed, and the process of recuperation continuously and sympathetically supervised, the chances are that recovery will not take place. Elliott Dunlap Smith and R. C. Nyman in the cotton-textile industry, and Elton Mayo in the electric-appliance industry have established facts and suggestions concerning human problems created in the plant that cannot be disregarded much longer.

Thus these human problems appear to be twofold: First, the machines themselves require carefully planned and continuous reorganization within the enterprise, the discarding of old plant layouts and of personnel and operating practice, and the drafting of new. Second, we are concerned with the social and economic environment in which the mechanized plant operates. The problems require the abandonment of patterns of a simpler government and the adoption of patterns for the government of a highly complex and dynamic order. They require that in the plant and in the industrial society that surrounds it, the techniques of executive control measure up to the dictates of the current technology. The two parts of the one great problem can be considered and solved separately only up to a point; each depends upon coordinated effort in an integrated whole.

My own inquiry into problems that cluster about the new machinery in the commercial printing office brought me into the same frame of conclusions that Mayo, Smith, and Nyman have reached. In the printing and cotton-textile changes the activities of strong unions formed an important part of the problem. Although the relations between unions and management were quite different, at least three important generalizations can be drawn from the two analyses:

1 The timing of the mechanization process was irrational.[1]

2 Mechanization was conducted in such a way that a substantial proportion of the employees developed active fear and resentment of the process.

3 Mechanization resulted in preventable losses both to management and to men.

In cotton mills studied the automatic loom was installed some 15 years before the plant was prepared to revise operating methods which the logic of the machine demanded from the first. Not until acute depression struck the industry and dividends were affected, were job burdens increased substantially and operating methods modernized. The process was spasmodic, too rapid, and without proper functional assignments among the personnel involved. What had been an exceptionally amicable spirit of cooperation between management and men broke up in a destructive strike. The lessons of this "stretch out" have been told with eloquent clarity by Messrs. Smith and Nyman.

In the mechanization of New York commercial printing pressrooms there was less foundation for smooth adjustments than in the cotton mill. Here too was a lag in plant mechanization of some fifteen to twenty years behind the invention of labor-saving equipment. During these years, as the organized employees pressed for better wages and hours they heard periodic threats from their employers that automatic machines would be installed to displace them. Thus in the prepara-

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[1] By mechanization is meant not only installation of labor-saving machines, but changes in operating methods and in the assignments of work to employees and executives.

tion for mechanization the men were taught to fear, hate, and resent the machines; and from the beginning of their installation a battle raged over the complement of men that should operate them, and the extent of skill that was required. Decisions made in a contest of economic strength could frequently be wrought only by recourse to an arbitrator whose business was no more than to find a reasonable *modus vivendi*. There was little or no knowledge, to say nothing of action, as to what should be done from the scientific point of view.

From the very beginning in commercial printing the division of labor in the pressroom has been unsystematic, and apprenticeship practice haphazard. On the management side this was probably due largely to the absence of competent personnel executives, together with the facts both social and economic that lay behind that absence. On the side of the employees, this lack of system was due partly to the fact that their first concern in connection with work was of themselves as consumers—of their wages, seniority rights, and the probability of continued employment—rather than as producers of commercial printing for the market. Furthermore, they were divided into several craft unions when negotiations would have been more efficient for both management and men had they composed a single union.

The shifts in personnel and in work assignments as new equipment was installed were uncontrolled and impulsive. For example, it was altogether possible for the foreman to take the opportunity to indulge his pet likes and dislikes by, on the one hand, encouraging those whom he wanted to retain or take on from outside by instructing them in the new methods, and, on the other hand, veiling the new job in mystery and putting the fear of it into those whom he intended to dismiss.

The continuous spirit of warfare that has accompanied mechanization of commercial printing in New York has always been heightened rather than soothed by the sharply competitive nature of the industry which has rendered management as price blind as the workers have been job blind. . . . . .

We have already gone far enough in analysis as well as in experience to find it ever more clear that successful installation of labor-saving machinery without adequate attention to the human factors involved is as impossible of achievement as corporate profits are impossible without a market for the products. Greater stability in production and employment and a smoother flow of goods and services from producer to consumer are environmental factors which appear to be essential for the creation within the plant of satisfied and willing groups of workers. Without this improvement it is questionable whether present fear of the machine can be converted into an interest in operating it efficiently. We must have not only a scientific integration within the plant of all the functions of personnel, machines, and operations, but outside the plant we must have an enlightened industrial government geared to its task.

In my opinion this outline not only permits but requires union organization of the workers. For, in a profit-seeking society, we have to remind ourselves that the struggle over the relatively residual portion of the income—the struggle over profits and real wages—will continue to force workers—despite excellent adjustments to their work as producers—to think of their status as consumers. Machine operators can give undivided attention to their work if they have confidence that their interests as consumers are being protected. It is scarcely necessary to add that the proper functioning of the collective bargain demands first-class leadership on both sides.

It should be observed that in industries which are contracting, the problems of adjustment are different from those which are expanding. But whether the plant or the industry is expanding, stationary, or contracting, technological obsolescence and change occur, causing breaks in the continuity of production and employment. If the organization, from high executives down to manual laborers, is kept attuned to change, and if the society which surrounds them is responsive—in other words if our shock absorbers in and out of the factory are as adequate as our engines—human problems will be well-nigh solved. Never before have we needed so much as now, for those in control of society as well as of industry, the true scientific spirit.

Recommendations such as those of the Wool Textile Work Assignment Board for a continuing plan for the industry seem to be in order toward a knitting together of our social, economic, and political organization to meet the present need. An organized and adequately administered labor market is also essential of course, as is vocational guidance and systematic re-education of displaced workers. (The Federal Vocational Rehabilitation Act of 1920 is a precedent for public fathering of this educational service.) And again, even if we provide for smoother running of industry amidst technological change the dynamic nature of our society requires provision for continuity of income, both psychic and material, when the chain of smooth procedure breaks. Social insurance is imperative. Tight-rope performers do their acts with inspiring sureness, but the saving net against emergency which is stretched stoutly below them plays a large part in courage and success.

In conclusion, my thesis is that we must work for a techno-culture worthy of our technology, so that labor-saving machines may be greeted as friends instead of enemies. In plant, in industry, and in society, American inventiveness which has devised these machines is now challenged more forcibly than ever before to make them effective for the benefit of mankind. I believe we are heading in the right direction.

Design of Light-Weight Compression-Ignition Engines

(*Continued from page 290*)

FUEL SYSTEM

The individual-pump system is common to a majority of small high-speed Diesel engines. This system has a high degree of reliability provided clean oil and reasonably good combustion are secured. Its chief drawback at the present time is the price. This appears to be out of all proportion to the rest of the engine structure, and until their units are reduced to about one quarter of their present price, or an injection system applied which comes in this price range, the real small high-speed engine is entirely out of the picture. Small six-cylinder gasoline engines in modest production can be sold for about \$1 to \$1.50 per hp. To buy an injection system for an oil engine of about the same size would cost about \$2 per hp, which is out of all proportion. The accuracy of the work involved in two parts, namely pump plunger and cylinder barrel, is above that of any engine. Allowing for this it is at once apparent that something must be done to reduce costs if we are to compete on a cost basis.

No objections are seen to some price differential, the fuel savings will take care of this. However, when the conditions of taxed fuel and a base price about equal to that of gasoline are encountered, the big differential at present existing will have to be eliminated in some manner, and here is one item of the equipment which will stand a good cut, even if a redesign has to be effected to do this.

PUBLIC WORKS *and the* BUSINESS CYCLE[1]

By OLIN INGRAHAM

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CONSIDERING only its physical aspects, the business cycle displays itself as giant oscillations in the production of long-time goods like buildings, and medium-time goods like automobiles, and by very much smaller oscillations in the short-time goods. In fact, it is arguable that these much smaller oscillations are themselves only the diffused effects of the large oscillations, that if iron workers and carpenters and automobile workers were laid off they would have less purchasing power to buy even food and clothing.

Well, then, it is tempting to go a step further and argue that if government ordered its long-time goods, mainly construction, in a cycle reciprocally timed to private demands, the business cycle would be diminished or abolished. Hence much argument but little accomplishment before 1934; hence the WPA; hence this volume to tell us what have been the cycles of government construction expenditures in the last fifteen years.

Gayer's work is mainly factual. Argument is brought in only secondarily. But near the end of the book there is a sober, careful chapter on "Basic Problems of Theory." In it he makes full acceptance of the importance of the fluctuations of long-time or capital goods in the business cycle: "The heart of the problem of business fluctuations has long been recognized to lie in this rise and fall of investment in new capital goods, both producers' goods and durable consumers' goods." He doubts the power of control by credit: "While it is probably true that some check can be effectively placed upon excessive activity in capital-goods industries on the upswing by the exercise of 'monetary' weapons alone, yet in themselves they would appear from recent experience to be powerless to restore the community's purchasing power once the reaction from excessive capital investment has occurred." Therefore he turns to public works and he finds that "a program of flexible, controlled public works may in its broader aspects be properly viewed as one special application of a fiscal policy which attempts to smooth fluctuations of activity by alternately accumulating balances in periods of prosperity and disbursing them during years of depression." He quotes Professor Louck's study of Philadelphia: "It was found that about 50 per cent of the total improvement expenditures from loan funds by the city proper could have been considered shiftable from one year to another during that period, and that had the city's expenditures of loan funds on municipal improvements been distributed over that period with a view to the reduction of unemployment, 10 to 15 per cent of the jobless could have been absorbed in any one year as a result. This percentage seems small, but there is reason to believe that it could be much increased were the long-range planning of public works adopted more systematically and prevailed over a wider area." Besides the people directly employed by public works, Gayer briefly deals with the problem of the residual additions to employment made by the increased demands of those who are directly employed.

Of course Gayer recognizes the difficulties and dangers in the expansion of public works and discusses under what conditions such expansion would mean a net increase, under what conditions would public works be a substitute for private works and still worse, under what conditions an expansion of public works would cause a greater contraction of private works.

There is the problem of reserves. If reserves are securities or bank deposits, then there are the practical problems of the forms in which they are maintained during prosperity; there is also the problem of their reduction and sale during depression. Reserves, of course, could be a margin of borrowing and taxpaying capacity that would exist even in a depression. But can we get the smaller political units to soberly preserve such a margin?

The final conclusion of the chapter is dubious enough: "An elastic public construction policy must ultimately be determined by the degree of faith they repose in the possibilities of the conscious and nationally planned guidance of economic activities."

And so we leave theory—but the great mass of the book is not theory but the orderly presentation of factual material in statistical form so that for the rest of us our theories need not be in the air. We can see, so far as statistical tables can show us, what has been the history of public works in the last fifteen years. There are first totals, and there we see that there has not been an expansion but a contraction during this depression. Then the author takes up the federal government. This is the one government body that has expanded its expenditures during the depression. The book carries us through this expansion to the PWA of the spring of 1935. There is also a chapter on federal financing. Fiscally it has been an easy operation to a form of government with such wide margin of unused borrowing and taxing power. Then it takes up the states and cities. There, in spite of the obvious need of employment, there was contraction of public works forced upon these smaller units by their narrow margin of taxation and borrowing. There is a special chapter on New York City. That city had already achieved by 1929 a public debt of $1,824,000,000, a debt much larger than the national debt in 1914. Then came the depression and the Empire State Building was nicknamed "The Empty State" building. Capacity to raise money by taxation was seriously threatened. But the debt kept climbing to $2,208,000,000 in 1933. No wonder expenditures on public construction in that city have fallen from $174,000,000 in 1929 to $63,000,000 in 1933, a reduction of more than a hundred million dollars. There is a chapter on local financing and an appendix on financial conditions of selected local governments during the depression.

What I get from this book, then, is the factual background to this theory of depression expansion of public works. I see, in the first place, it is a theory that has never been tried. Before 1929 we talked about the theory leisurely, but then we knew we were in a new era in which serious depressions could not occur. After 1929 we talked about it distractedly while the total of government expenditures fell and fell. This may seem a strange statement to those whose eyes are focused on Washington. The federal government is now spending far

[1] "Public Works in Prosperity and Depression," by Arthur D. Gayer. National Bureau of Economic Research, New York, 1935, $3.

One of a series of reviews of current economic literature affecting engineering prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers.

more on public works than it spent in 1929. But the federal government's expenditures on public works was only 11 per cent of governmental expenditures on works (only two and a fraction per cent of the total of public and private expenditures), while cities and counties accounted for 68 per cent of governmental expenditures. Then came the depression. What availed that federal expenditures on public works rose from 307 million dollars in 1929 to 556 million dollars in 1932? What availed even that the PWA should spend 892 million dollars from July 1, 1934, to April 30, 1935 (the last figures given in the book), so long as cities, counties, and states decreased their expenditures on construction from 2471 million dollars in 1929 to 800 million dollars in 1933? Combining all government units together, the cycle of government expenditures on construction moves with the cycle of private expenditures, though in an oscillation of smaller percentage. It is estimated that all public-works expenditures fell from 3555 million dollars in 1929 to 1300 million dollars in 1933, while private expenditures fell from 8724 million to 1477 million dollars. The one fell 63 per cent, the other 83 per cent. They both fell enormously.

Well, suppose this depression is interpreted pretty generally by the public in such a way as to emphasize the need of prompt expansion of public works to meet future impending depressions. Suppose the federal government becomes fiscally as strong as it was in 1929. By the way, if that were so there would be no need for any special fund for meeting federal expansion, would there? Suppose that the government had its plans prepared and its administrators were ready on their toes. There could very easily be a rapid expansion of federal works. What about the cities? Suppose in the main they become like the cities of 1929 in government, in fiscal strains. Suppose they have been under pressing problems of modernization and expansion in the previous period of prosperity. Would they have added to their tax burdens then to provide a fund to meet a depression at a time unknown of an amount unknown? And if no fund has been provided, can they meet it by current borrowing or current taxation? And if they can, will they? It is so much cheaper to provide relief for one's own unemployed than to provide local employment plus materials ordered from all over the United States. Of course if cities were the creatures of central governments as in Italy, there would be no difficulties. They draw their fiscal strength from the nation. They would contribute to the fiscal strength of the nation by their outside orders for building material. In the United States it is more difficult, but in this depression we have used the federal strength for the support of local projects, and we could have done that much more promptly if before the depression there had been any preponderant agreement on the desirability of depression expansion.

While we are considering how not to reduce public-works expenditures from 3555 million to 1300 million dollars, don't forget the larger problem of how not to reduce private-works expenditures from 8624 million to 1477 million dollars.

MACHINE AND ELECTRIC SHOP—PUGET SOUND NAVY YARD, BREMERTON, WASH.—FEDERAL PUBLIC WORKS PROJECT NO. 40

ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

New British Bombers

ON THE design and technical progress of aircraft the political events of the year are bound to have a potent effect. Since the end of the War technical developments, great as they have been, have proceeded without much stimulus from international competition in a military sense. The British Government's disarmament policy did not encourage either numerical or technical competition. British manufacturers and research departments were not pressed unduly in their efforts to develop aeronautical practice and science. In some respects the conditions were, perhaps, made too easy by the absence of serious foreign rivalry. A tendency developed to concentrate on the improvement of well-tried types of machines rather than to launch out into new designs. Perforce that tendency is today continuing to exert its influence on the steps being taken to satisfy the British Government's program of expansion. It would, however, be folly to ignore the fact that the re-entry of Germany into the circle of the world's air powers has completely changed the situation. Germany, a first-class scientific nation, is rapidly building up her air force with machines of types which have not been evolved from earlier designs, but which embody, in fact, a fresh outlook on military aeronautics. In England it is obvious that some of the designs on which they have placed reliance for a number of years have reached the limit of their possible development. If they are to maintain their position not only with respect to numbers but as regards technical quality and performance it is essential that the changed conditions of the international situation which the last year produced should be fully borne in mind. To put it briefly and to deal with one aspect only; they must no longer think in terms of 250 miles an hour speeds but concentrate on at least 350.

Of great interest is the Mayo composite aircraft, Fig. 1. This combination has been designed to meet the requirements of a direct transatlantic air-mail service. It consists of a flying boat generally similar to the four-engined monoplane boats which Short Brothers are building for the company, together with a monoplane float seaplane driven by four Napier "Rapier" engines. The intention is that the two crafts should take off locked together and that when flying height has been reached the lock should be released; the float seaplane proceeding to cross the Atlantic while the larger lower unit returns to its base. It is not very clear in what respect the arrangement is superior to one based on flying the long-range machine with a light load of fuel to the requisite height and there refueling it from a feeder machine before it sets out on its journey. The fact, however, that the Air Ministry seems to be officially interested in the experiment (with an eye possibly on the use of a similar combination to facilitate the start of a heavily laden long-distance bomber), suggests that the scheme has more aeronautical merits than are obvious at first sight. It is expected that flight trials of the composite aircraft will be begun in August.

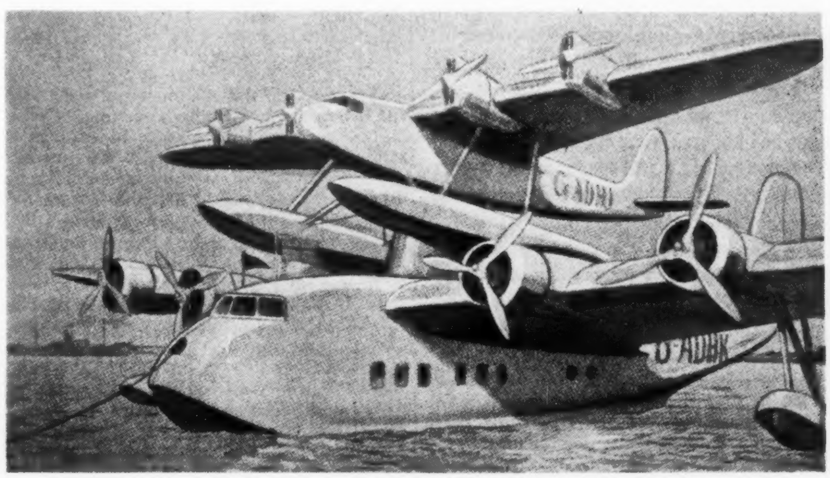


FIG. 1 MAYO COMPOSITE AIRCRAFT

A machine of exceptional interest, the "Fantôme" multigun single-seater fighter, was produced by the Fairey Aviation Company, to meet a specification of the Belgian Government. The specification called for a top speed of at least 250 mph and an armament consisting of a 20 mm "cannon" and four machine guns. This machine is claimed to be one of the most formidable fighting aircraft ever produced. Its primary duty is defense against formations of bombers. The "moteur canon" fires through the hollow airscrew shaft and can discharge shells at the rate of 260 per minute. Two of the 0.303-caliber machine guns are mounted within the lower wings outside the airscrew disk. The two others are disposed within the fuselage alongside the cannon and fire through the airscrew disk with the aid of Constantinescu interrupter gear. All the guns are loaded and cocked by means of compressed air which is also used for operating the trigger motors of the wing guns and for the firing control of the center guns. The engine is cooled by means of ethylene glycol; the radiator, of honeycomb pattern, is situated in a tunnel beneath the body and between the undercarriage legs.

The equipment of the machine includes electric lighting and heating, wireless transmission and reception, and oxygen apparatus. With its high speed, the concentration of fire from its machine guns, and the increased range of the cannon, this aircraft will doubtlessly go a long way toward causing a great change in air fighting tactics. At the S.B.A.C. display at Hendon on July 1 the "Fantôme" gave a remarkable demonstration of its qualities.

ENGINES

No limit can yet be placed on the size of engine which might usefully be employed. In responsible quarters discussion has taken place regarding the development of large aircraft. The possibility has been mentioned of building a flying boat having a total weight of 200 tons. Such a boat would require six or eight airscrews, each driven by an engine or engines developing about 5000 hp. It has not yet been decided whether such power is better generated by a single unit than by a number of units grouped round a common shaft. The second-named alternative is possible at the present moment. The first is not but doubtlessly if it can be proved to possess considerable advantages will in due time be made practicable.

It might appear that the compression-ignition engine would promise to be the most hopeful direction in which to seek units of increased power. At present, so far as authentic information extends, they have the Bristol "Phoenix" air-cooled compression-ignition engine of 350 bhp, the Napier "Cutlass" water-cooled of 535 bhp, and the Napier "Culverin" water-cooled of 730 bhp. Experimental work is being carried out by others, in particular by H. R. Ricardo, who, working on behalf of the Air Ministry on a two-cycle, sleeve-valve, compression-ignition engine, has developed a single-cylinder unit giving an output of 32 hp per liter. The development of the compression-ignition engine is, however, still suffering from the continued progress of the gasoline engine, so much so that the superior efficiency of the compression-ignition engine is now by itself scarcely sufficient to justify its adoption in preference to the gasoline engine. For a time it seemed likely that the compression-ignition engine would be regarded with favor because it was free from a real source of danger and trouble found in the gasoline engine, the icing of the carburetor resulting from the joint effect of a low atmospheric temperature and the cooling caused by the evaporation of the gasoline. To overcome this difficulty in the gasoline engine attention has been di rected to the possibility of employing direct gasoline injection instead of its atomization in a carburetor. Good results are understood to have been achieved, but meanwhile an alternative solution of the problem of even greater promise has been found.

The formation of ice in a carburetor, it has been discovered, can be prevented if a little alcohol is mixed with the gasoline. The continuous addition of alcohol whether the circumstances require it or not is, however, objectionable because it introduces corrosion and other difficulties. An automatic device has, therefore, been produced at the Royal Aircraft Establishment which causes alcohol to be introduced into the float chamber of the carburetor only when freezing conditions are encountered. The automatic action is derived from an ice detector situated in the air intake passage. This detector consists of a small orifice which when it becomes blocked with ice causes the pressure on the two faces of a diaphragm to become unbalanced and the alcohol valve to be opened.

Side by side with this removal of one of the chief operational objections to the gasoline engine, its fuel economy has recently been greatly increased by the development of automatic mixture-control devices which correctly regulate the mixture strength according to the altitude of the flight. Trials extending over three months are stated to have shown a saving of 14 to 30 per cent of fuel, as compared with the usual manual adjustment of the mixture strength. Another direction in which fuel economy is being sought lies in the use of very weak mixtures in conjunction with ignition advance. With some engines, a saving of fuel amounting to as much as 17 per cent has been indicated as attainable by this procedure.

With these advances in the efficiency and trustworthiness of the gasoline engine it would appear that the compression-ignition aeronautical engine, in spite of the progress which has been made with it, is still at a handicap to its rival. (*The Engineer*, vol. 141, no. 4173–4, Jan. 3 and 10, 1936, pp. 2–4 and 49–50, illustrated)

AIR CONDITIONING

Turbine-Driven Compressors

DUE to the variable nature of the load and to the location of machinery near places of public assembly, air-conditioning systems other than railroad have heretofore largely been driven by electric motors. The only exception was where there was plenty of exhaust steam in which case the steam-jet system became a contender.

In the present article is described a steam turbine which can run on the exhaust system in buildings, such as hotels and stores. It drives a centrifugal refrigerating compressor. As regards the types of turbine used for this purpose the following are the most generally used:

High-Pressure Condensing. This is preferable when the user operates a steam-generating plant or purchases high-pressure steam and has no use for low-pressure exhaust steam.

High-Pressure Noncondensing. When high-pressure steam is available at very low cost, or when the need exists for lower-pressure steam, the high-pressure turbine operated noncondensing is usually best adapted.

High-Pressure Condensing or Noncondensing. The turbine designer is often called upon for a turbine of this type, as it has wide application in industrial use and is used to some extent in air conditioning. A stadium is a typical application, where the turbine is run noncondensing in winter to drive a refrigerant compressor for producing ice on a skating rink, and the exhaust steam is used for heating the stadium. In summer when refrigeration is required for air conditioning the turbine is run condensing to develop the greater horsepower required for driving the compressor at a higher suction temperature and correspondingly higher tonnage. The centrifugal machine has characteristics very favorable for this service.

Low-Pressure Condensing. The low-pressure turbine, operated condensing, enables the engineer to use to advantage the final increment of energy from steam. Such low-pressure steam is often available as exhaust from steam engines or other steam-driven equipment. If a sufficient quantity of steam is available, it may be used even at pressures below atmospheric. A notable example of this is a large department store in New York City where turbines are used for driving centrifugal compressors with steam at 1 in. vacuum. The steam is expanded to 28 in. vacuum in this particular installation. It is obvious that such complete utilization of available energy represents a saving, so long as condenser-water requirements and capital investment are within practicable limits.

If condenser water is purchased or pumped from river, lake, or well, double use can be made of it by running it in series, first through the refrigerant condenser and then through the steam condenser. Thus condensing of turbine exhaust can be had without additional expense for water, with a limited supply, as from a well, or with smaller pipe lines and pumping equipment.

Several types of governors are briefly referred to and illustrated in the original article.

The maintenance costs of steam turbines driving centrifugal compressors are low. A recent survey covering some 23 installations made over a period of approximately ten years (average operation

six years) shows the total cost of repair parts to average about $16 per turbine per year.

Centrifugal gas compressors are in commercial use for air conditioning, ranging in speed from 3000 to 20,000 rpm, but a large percentage of these installations work within the lower limits of this speed range, say from 3000 to 5000 rpm. This speed range suits the steam turbine admirably for low first cost and economical operation.

Since the pressure ratio, and therefore the temperature difference, between high and low side can be varied by changing the rotor speed, the same compressor may be used for a wide field of application simply by designing the drive for the proper compressor speed. In many instances the same gas compressor that is used for air conditioning may be used for ice making, or cooling brine to a low temperature for process work simply by increasing its speed.

The author describes next the several installations where turbines were used in air-conditioning jobs. Among these installations were two—one at Gimbel Brothers, and the other at Saks Department Stores in New York City. Here the conditions of operation particularly favored the employment of steam turbines for driving the refrigerating units.

Two machines were installed, one having a capacity of 600 tons, and the other a capacity of 200 tons. The two machines were interconnected so that either may be used for supplying refrigerated water to both stores. The larger compressor is driven by a 610-hp steam turbine at a top speed of 4000 rpm. The smaller compressor is driven by a turbine a little over 200 hp at a top speed of 4060 rpm. Both turbines are of a high-pressure condensing type designed to operate on steam at 100 lb per sq in. and exhaust at a 26-in. vacuum. Forced-feed lubrication and fluid governors are used. The turbines are direct-connected to the compressors, one of which is of the two-stage and the other of the three-stage type, by flexible couplings. An added refinement is the use of an oil-purifying system for turbine oil circuit.

Condensing water is cooled by a forced-draft cooling tower and is used through the two refrigerant condensers in parallel, then passing to a common steam condenser; 2800 gal per min of water is used for condensing. Since this water is recirculated through the system, and all steam is condensed for return to the boilers, the only water supplied to the system from an outside source is that used for make-up due to evaporation.

A further step was taken in the application of steam turbines in driving both the condenser and chilled-water pumps by one turbine, both pumps being direct-connected, with the chilled-water pump which was placed adjacent to the turbine.

Another installation described is that of the New York Cold Storage Co. This is considered one of the most revolutionary steps in the cold-storage industry in some time. A 60-ton unit, consisting of a three-stage centrifugal compressor with a single-stage centrifugal booster in the refrigerant circuit, is used to cool calcium brine to a temperature of —15 F. Both compressors are driven by a 135-hp steam turbine, the multistage compressor being connected directly to the turbine through a flexible coupling and the booster driven from the rear of the compressor through a flexible coupling. (J. H. Koonce and R. E. Cherne, *Refrigerating Engineering*, vol. 30, nos. 3 and 4, Sept. and Oct., 1935, pp. 136–138 and 172, and pp. 193–195, illustrated)

ENGINEERING MATERIALS

Wire Ropes Research

THE following abstract is based on the recently published fifth report of the Wire Ropes Research Committee of the Institution of Mechanical Engineers. This brings to conclusion some sixteen years of work in a field where little experimental evidence was previously available. The fifth report deals with check tests of a 2-in. commercial rope No. 26 as well as some other ropes. An attempt was made to discover whether slip between rope and pulley was the cause of any reduction of rope life at higher speed. The evidence obtained indicated that pulley slip did not add to the severity of treatment at high speeds and the report suggests that the destructive effect of higher speeds may be due to higher accelerations increasing the effective rope tension.

Among other things it was found that, all other conditions being identical, the ropes had shorter life when lubricated than when tested dry. The conclusion was reached that the rope dressing should be selected to protect the rope against corrosion and not as a lubricant. It has also been found that the rope broke sooner when used on a chilled pulley than on a cast-iron pulley. Other experiments indicated that the material forming the pulley groove was a factor affecting the life of the rope. Aluminum of all the metal grooves gave the longest life to the rope but the pulley tread wore very badly. A groove filled with plastic wood gave excellent results.

Tests on ropes of special sections are reported in the original article.

The earlier reports contained enough information to enable those interested to deduce, for a given performance, the relation between the diameters of pulley, rope, and wire; but the process was rather complicated, and a special series of tests was therefore undertaken, to demonstrate the relationship more directly. If all wires were parallel to the rope axis and no friction existed between them, the bending stresses would depend on the ratio of pulley to wire diameter; but the bending stress was affected by the shape of the wire in the strand and of the strand in the rope, and also (to an extent difficult to estimate) by the resistance to relative movement of the wires. If a strand were completely locked, and in effect solid, the strand diameter should be taken, instead of the wire diameter, to calculate the bending stress; and if the interaction of the wires affected all types of strand in the same degree, the pulley diameter should be based on the wire diameter which earlier reports showed to be incorrect. With more complex strands, the interaction of the wires had an effect in opposition to, and possibly exceeding, that due to the apparent reduction of bending stress through the use of smaller wires.

The present use of a "factor of safety," divided into the breaking strength to give the working tension, was misleading, and was responsible for various misconceptions. The ratio of rope strength to tensile load should not be called the "factor of safety," because it neglected the bending stress on the wire, which was usually greater than the direct tensile stress due to the load.

The tests demonstrated that a larger pulley insured a much greater rope life. (*Engineering*, vol. 141, no. 3651, Jan. 3, 1936, pp. 25–26)

FUELS AND FIRING

Distribution of Powdered Fuel

AMONG the Fuel Research Station's exhibits at the Physical Society's Exhibition (Great Britain) was a model of an arrangement for the distribution of powdered fuel. In certain powdered-fuel installations it is essential for the air-borne fuel to be divided into two or more exactly similar streams so that it may be distributed to a number of burners. Owing to the fact that fuel across the original stream is not uniform, either as regards the concentration or the size

of the particles, it has proved very difficult to separate the streams into two or more equal parts. In the model that was exhibited, however, the whole cross section of the main stream is divided into

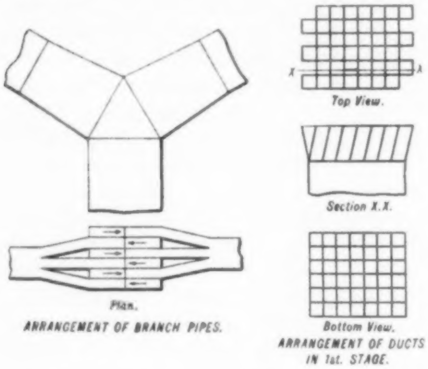


FIG. 2 TWO-WAY DISTRIBUTOR FOR PULVERIZED FUEL

a large number of small squares, Fig. 2, each of which is the entrance to a duct. By suitably inclining alternate rows of ducts the air and fuel are led into two branch pipes connected to powdered-fuel burners in such a manner that no two adjacent squares in the main stream supply the same burner. The method is being successfully employed on a number of Lancashire boilers to supply two furnaces with equal quantities of air and fuel from a single unit pulverizer. Although originally devised for the purpose just mentioned, the device can be used in several other ways, e.g., for sampling large or small solids and for mixing any form of fluid material. A full description of the scheme was given in the October 4, 1935, issue of *The Engineer*, in connection with the Engineering and Machinery Exhibition at Olympia. (*The Engineer*, vol. 141, no. 4176, Jan. 24, 1936, pp. 105–108, illustrated)

Fusain in Coal Dust

THE subject of natural recovery of very fine dust was investigated in the belief that a certain natural concentration of fusain could be obtained if a very fine material were collected separately, previous work having indicated that the fusain was contained mainly in the minus-200-mesh material. The results are given in Tables 6 and 7 and illustrations in the original article and show that the fine material obtained was composed mainly of fusain and that the ash content of the size fraction in a given series rises regularly with decrease in size to a maximum at about plus 150-mesh and then decreases.

As regards practical application of fusain-rich dust a recent work in Germany indicates that the naturally formed fine sizes of coal tend to have a higher phosphorus content than does the entire coal so that the removal of this fine high-phosphorus dust would be of definite value in an effort to produce low-phosphorus coke. It is contended also that the coking properties of the fine sizes of Illinois coals may be improved by dedusting in which process the friable and noncaking fusain is largely removed.

The use of a pneumatic process for removing fine material (usually less than 48 mesh) is increasing in the preparation of stoker-size coal. The fine material produced as a by-product is known as dedusting-plant dust. Since fusain is the most friable ingredient in bituminous coal (it may readily be rubbed to an impalpable powder with the fingers), it tends to accumulate in this by-product.

While studying the properties of cokes produced by blending Illinois coals with other materials, considerable quantities of fusain were required. Dedusting-plant dust suggested itself as a convenient supply. It became necessary, therefore, to determine how much fusain was contained in a measured sample of dust, how the fusain was distributed with respect to size and specific gravity in the sample, and whether or not it would be feasible or desirable further to concentrate or to recover the fusain from the dust before using it in the blends to be coked. The results obtained indicate the possibilities of production of a high-fusain material.

Since the various banded ingredients of coal have different specific gravities, it should be possible to effect a separation of fusain from the remainder of the dust by a float-and-sink procedure in liquids of different densities, or by some other procedure based on a difference in specific gravity. The experimental results, however, were not encouraging because of the difficulties encountered in separating such finely divided material. The separation of fusain was not as satisfactory as that obtained by sieving. Even a fair estimate of the fusain content of the various gravity fractions could not be made without further sizing. (Paper before Feb., 1936, meeting of A.I.M.E., Technical Publication No. 664, Class F, Coal Division No. 70, by Gilbert Thiessen, 12 pp., 5 figs.)

INTERNAL-COMBUSTION ENGINEERING

Bristol Wobble-Plate Engine

THIS engine is a nine-cylinder unit with a cylinder bore of $3\frac{1}{2}$ in. and a piston stroke of $5\frac{1}{8}$ in., giving an R.A.C. rating of 44.1 hp. The maximum output of the engine is in the neighborhood of 150 bhp. The engine is extremely compact and roughly resembles a turbine in appearance. The actual space occupied is about two thirds of that of a conventional engine of similar power, and the weight is some 5 cwt less than that of the corresponding Bristol engine with cylinders in line.

The wobble plate is in the form of a hollow disk with inclined sides. The bosses of this plate are mounted on ball bearings on the crankpin of a Z-shaped crankshaft. The inner end of the crankshaft is carried on two roller bearings mounted on the end cover of the engine, while the outer end is carried on ball and roller races in the center of the cylinder block and in the cylinder-head casting. A torque member projecting through a slot in the wobble plate allows the plate to wobble freely while preventing its rotation. The connecting rods are connected to the plate by spherical bushes engaging with balls around the circumference of the plate. The crankshaft is very short and can therefore be made correspondingly stiff, and although the engine has nine cylinders, only four principal bearings are necessary, two main and two crankpin bearings.

The arrangement of the wobble plate and cylinders results in only a small angularity of the connecting rods, not exceeding $\frac{1}{2}$ in., and as a result of this, in conjunction with the small number of bearings, the engine has a high mechanical efficiency. Only about one third the power is required to motor the engine as compared with the Bristol model.

The piston is a symmetrical forging without bosses, the gudgeon pin being replaced by a half ball provided with a flange. The end of the connecting rod is cup-shaped, and is held onto the half ball by a split cap of spherical form, held in place by six studs. The two halves of the split bushes engaging the balls on the wobble plate are pressed into the big ends and secured there. The whole piston assembly weighs only about one third of the corresponding assembly for an in-line engine. A rotary-valve system is employed, there being a single port in the end of each cylinder into which is fitted a hollow piston having a flange at its outer end.

Tests of the engine have established a fuel economy of about 16 per cent as compared with a conventional type and both the reciprocating force and couples can be completely balanced. (Part of a serial article entitled, "The Commercial Vehicle Exhibition at Olympia," in *Engineering*, vol. 140, no. 3646, Nov. 29, 1935, pp. 571–572, 1 fig.)

MACHINE PARTS

The Nomy Bearing

THIS bearing, developed by a Swedish concern, is based on the Michell principle of dividing the bearing surface into eccentrically supported pads which are free to tilt, thus forming a tapering film of oil between the bearing surfaces. The design is decidedly novel and the bearing is fully described and illustrated in the original article. A bearing is referred to that is intended for very light loads and running at high speed with induced flow of air as a lubricant. It is stated that air-lubricated bearings, both of the thrust and journal types, have successfully completed test runs of several months' duration without showing any signs of wear. The air-lubricated bearing is, however, only a comparatively minor development in the new type. (*Engineering*, vol. 140, no. 3646, Nov. 29, 1935, pp. 577–579, 7 figs.)

MACHINE-SHOP PRACTICE

Hardening Characteristics of Tool Steels

INFORMATION has been accumulated to remove much of the mystery that had surrounded the causes of marked differences in the hardening characteristics of steels of apparently identical chemical compositions. The so-called "body" or "personality" of tool steel as evidenced by depth of hardening and fracture tests has not been recognized as an important factor in the hardening of carbon tool steels.

Shepherd described a simple test for depth of hardness penetration and Luerssen pointed out the desirability, as well as the possibility, of controlling melting conditions to produce carbon tool steel with a predetermined hardness penetration and quenching-temperature range. Such tool steels were shortly made available commercially.

The conception of the hardening of tool steel as dependent upon austenitic grain size rapidly became widely accepted. The influence of the "initial structure" of the steel (the structure prior to heating for hardening) upon the austenitic grain size, and hence upon the hardenability, was also recognized by those most active in developing the theories of grain-size effects. This factor has, however, received less attention than many other phases of austenitic grain-size influence.

The experimental work described in this paper was done as a part of a comprehensive study of the characteristics of commercial 1 per cent carbon tool steels. Particular attention was given to the influence of the initial or prehardening structure upon the grain size and grain-growth characteristics of austenite in and above the usual ranges of hardening temperatures for the steels considered.

The experiments were carried out on two commercial 1 per cent carbon steels, and the data thus secured permitted the derivation of grain size and critical-cooling-rate relations throughout this range of temperature.

For quenching temperatures below that at which all the carbon is completely dissolved in the austenite, both austenitic grain size and critical cooling rates are influenced to a large degree by the initial structure of the steels. Above this temperature each steel approached both a grain size and a critical cooling rate which was characteristic of the steel regardless of its initial structure.

In the correlation of austenitic grain size with critical cooling rates the non-controlled grain-size steel showed a marked effect of grain size throughout the entire range of quenching temperatures. The influence of the initial structure was also evident at the lower quenching temperatures.

The critical cooling rate of the controlled grain-size steel changed appreciably with little or no change in austenitic grain size. At the lower quenching temperatures difference in carbon content and carbon distribution in the austenite may be the controlling factors, but at higher temperatures oxides or carbides introduced for grain control are probably the effective factors in changing the critical cooling rate.

The initial structure of the controlled grain-size steel exerts an influence on the grain-size-critical-cooling-rate relations at both low and high quenching temperatures. (T. G. Digges and Louis Jordan, Transactions of the American Society for Metals, vol. 23, no. 4, December, 1935, original paper, pp. 839–856, 7 figs., and discussion, pp. 856–860)

MARINE ENGINEERING

Future of Steam Propulsion

THE author is mainly concerned with the faster type of ocean-going passenger vessels having an aggregate power of not less than 20,000 shaft horsepower.

He thinks that in high-powered vessels steam is supreme today and is intrinsically capable of maintaining an unassailable superiority. In an installation of, say, 20,000 hp the difference between the daily consumption by weight of fuel of Diesel and steam would be about 20 tons in favor of the Diesel but the steam installation would be about 500 tons lighter so that there would be little to choose between the combined weights of machinery and bunkers for 10,000 miles.

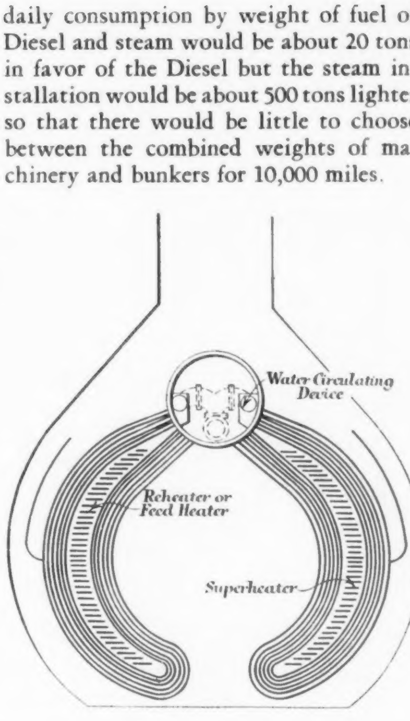


FIG. 3 ONE-DRUM MARINE BOILER

The author gives figures for what he apparently considers as an ideal mercantile boiler complete with preheater. Fig. 3 shows a boiler with one drum only having fairly small tubes, assisted circulation, and a finished weight of 80 tons for an output in service of 80,000 pounds of steam per hour. The propulsion of freight vessels is considered somewhat briefly. (*Engineering*, vol. 141, no. 3654, Jan. 24, 1936, serial article, pp. 105–106)

Operating a Double Compound Marine Steam Engine

THIS engine is a further development of the Woolf design which has been made in the expectation that with the usual pressures of 12 to 15 atm gage as used for aggregates below 2000 hp and with superheat up to 350 C, the heat exchange would be so small that the entire temperature drop could be utilized in two stages. It was estimated that the construction would fully meet the requirements of this simple valve gear and this has been achieved by using a single valve as the organ controlling the distribution for both cylinders and by building the low-pressure cylinder as a straight-flow unit. The two inside bands of the valve serve to control the distribution of steam in the high-pressure cylinder and the cut-off in the low-pressure cylinder, while the outer small bands control an additional exit of steam from the low-pressure cylinder. As the compression cannot be carried above the admission pressure,

instead of using full valve rings narrow double rings are employed and stay tighter over a longer time.

The design of the cylinder is so simple that the two cylinders with the valve

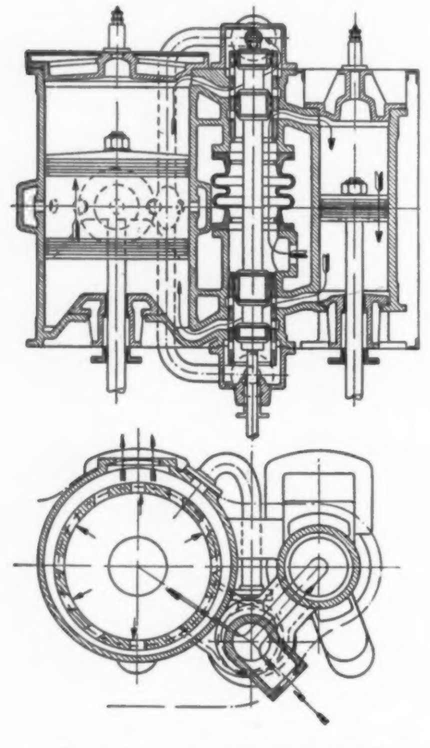


FIG. 4 VALVES OF THE DOUBLE COMPOUND MARINE STEAM ENGINE

just referred to have low-pressure cylinders not to exceed 900 mm and are cast in one piece. The price of a double compound engine is lower than that of a three-stage expansion engine of a similar output. The individual parts are said to be lighter. The indicator diagram, Fig. 5, shows the quality of the distribution of the steam. It clearly shows how the heat losses have been reduced during the passage from one cylinder to another through the selection of the distance between the high-pressure steam exit position and the low-pressure cutoff line.

Among the data on performance the following may be cited. On the fishing vessel *Oskar Neynaber* equipped with a double compound engine rated at 650 ihp normal output, the following consumptions were found with the specified cutoffs in the high-pressure cylinder:

At 35 per cent the steam consumption was 4.49 kg per ihp-hr; at 40 per cent, 4.6 kg; and at 45 per cent, 4.82 kg. It is said that the best engines of the triple-expansion type have consumptions higher by more than 15 per cent for the same output.

Another concern had six steam vessels equipped originally with steam turbines and double-reduction gears. The economy was poor as the plant had a ca-

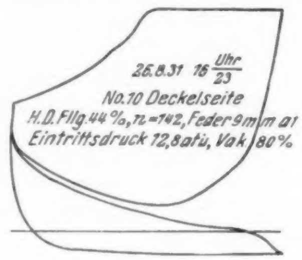


FIG. 5 HIGH- AND LOW-PRESSURE CYLINDER INDICATOR CARDS OF THE DOUBLE COMPOUND ENGINE

(*Uhr* = o'clock; *Deckelseite* = cover side; *H.D.* = high-pressure cylinder; *Fllg.* = cutoff; *Feder* = spring; *At* = atmospheres; *Eintrittsdruck* = admission pressure; *Atü* = atmospheres gage; *Vak.* = vacuum.)

pacity of only 500 to 600 hp. The turbines were taken out and replaced by triple-expansion engines which, in turn, were replaced by double compound engines of the type described in the original article. The figures of coal consumption of the various boats of this group are given in the original article. It is stated that the double compound engine has given an improved economy of 24 per cent as against the turbine plant and 16 per cent as against the triple-expansion engine. (S. Bock in *Schiffbau*, vol. 36, no. 14, July 15, 1935, pp. 221–223, 4 figs.)

Marine-Engine Failures

THIS is an editorial based on a paper delivered on Dec. 10, 1935, to the Institute of Marine Engineers by S. F. Dorey, entitled, "Marine Machinery Defects—Their Causes and Prevention."

Among other things the author says that the greater number of the failures in crankshafts and in other engine parts appear to be due to stress concentrations caused by oil ducts, bolt holes or other sudden changes in section; and it is clear that there still remains today an urgent need for greater ingenuity in the drafting room in respect to such details—although it must be admitted that, without increase in weight, stress concentrations can never be wholly eliminated. Much may be learned from laboratory fatigue tests on models, because laboratory tests can be so controlled as to yield data in a definite manner; and it is much to be hoped that research on model parts will continue actively.

It is unfortunate that, in the case at least of bending tests, research has indicated that the fatigue-limit values for very small test pieces are not reproduced in tests on larger pieces, the latter being relatively more susceptible to fatigue. For this reason, a so-called size factor *k*—greater than unity—is now coming into general use to represent the number by which the tested fatigue limit of a small sample must be divided to obtain the corresponding limit for a large shaft. This factor commonly varies from unity up to 1.5 or more, according to the character of the steel. The need for this factor would disappear if it were possible to use larger pieces of about 3 in. diameter in the tests.

In this connection, it may be noted that the fatigue limit determined in direct alternating stress—under pull and push as in the Haigh machine—is never quite as high as, and commonly much lower than, the value determined for the same material when a small sample is tested in the ordinary Wöhler bending machine. The ratio changes from unity up to about 1.5 in this case also, and it seems not improbable that the cause may be the same as that of the size effect in Wöhler tests. In direct stress tests, the whole section and a considerable length of the test piece are subjected to the full range of stress, and the conditions correspond closely to those that exist in a very large bending-test piece. (Editorial in *Engineering*, vol. 140, no. 3649, Dec. 20, 1935, pp. 667–668)

MOTOR-CAR ENGINEERING

Cappa Two-Stroke-Cycle Diesel Engine

THIS engine, shown in cross section in Fig. 6, has parallel, opposed, double-acting pistons driving a crankshaft located under the cylinders through a laterally supported oscillating level. The horizontal arrangement of the pistons does not appear to lead to any trouble in this case, because the long lever arms and oscillating lever necessitate only short piston travel.

The lower part of the cylinder carrying the pistons has no exhaust ports and therefore no hot port parts. The arrangements of opposed pistons selected by Cappa necessitates the use of the jet atomization process, which, however, gives a very low specific fuel consumption, though it is not particularly suitable for vehicle operation.

The scavenging air is supplied by a Roots blower running at double the crankshaft speed and driven the same as the injection pump through a chain. The motor block is an aluminum casting with inserted hard cylinder liners, and the connecting rods are round and hollow-

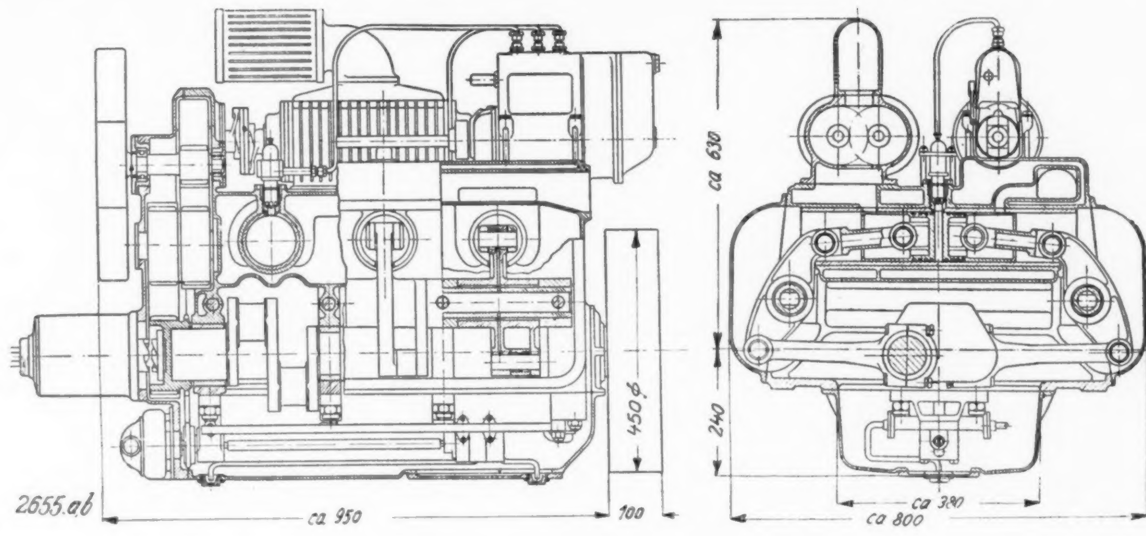


FIG. 6 TWO-STROKE-CYCLE CAPPA DIESEL ENGINE

bored. The fuel consumption is said to be 170 grams per effective hp-hr; oil consumption 5 grams per effective hp, and weight without flywheel 450 kg. (*Automobiltechnische Zeitschrift*, vol. 38, no. 19, Oct. 10, 1935, p. 489, 2 figs.)

POWER-PLANT ENGINEERING

Aerodynamics of Fuel Motion in Furnaces

THE processes of flow in a furnace come to a final state due to the fact that the velocity of combustion is essentially a function of the velocities of the supply and distribution of the air of combustion over the surface of the fuel and its thorough mixture with the combustible particles of gas. As against other technical processes of flow the processes that take place in the fuel bed of a furnace vary in general in time and in space. With a given velocity of combustion, the path of flow is determined by the size and composition of the particle, and the thickness of the bed, the temperature also being one of the factors affecting the process.

Two different groups of processes have to be considered here. The distribution of flow may be either constant within certain limits of variation or it may vary in an irregular and unstable way because of uneven accumulation of ashes, local instability of the layer of fuel, etc. The theoretical and experimental treatment of the processes of flow in the materials may proceed in two different directions. The deposition of the fuel may be considered either as a simple whole or as a sum of similar parts, or an attempt may be made to grasp the entire process of flow from the unstable irregular arrangement of the single particle.

The possible ways of building up deposits lie between the limiting cases, namely, the deposit which is thoroughly mixed and that which is entirely unmixed. Experiment and calculation show the fundamental difference between the two limiting forms of particle separation, which, for the sake of simplicity, may be designated as series or parallel

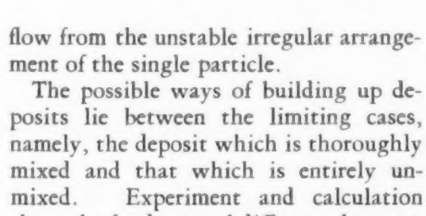


FIG. 7 COMPARISON OF PERMEABILITY TO FLOW IN THE TWO LIMITING CASES OF SEPARATION OF GRADING AS A FUNCTION OF CONTENT OF FINE-GRAINED COAL

(V = permeability to flow expressed in terms of cubic meters per sec and square meters of the total area over which the ashes fall, assuming a unit value of loss of pressure per meter of height of drop; d_f = size of particle of the finer deposits; d_g = size of particle of the coarser deposits. Note in particular the fact that the scales of ordinates in Figs. 7*a* and 7*b* are not the same. *Anteil des Feinen* = the part of the fine grain in the total coal; *Laminarstromung* = laminar flow; *Turbulente Stromung* = turbulent flow; *Schema der entmischten Schüttung* = diagrammatic presentation of separated precipitation of noncombustible material; *Feinkorn* = fine coal; *Grobkorn* = coarse coal; *Korngrossen-verhältnis* = ratio of fine to coarse coal.)

arrangement of the coarse and fine particles in the direction of flow (Fig. 7). In the series arrangement, in which the different classes of particles follow each other in layers in the direction of the flow, the quantity of each class of particles is the same (cu m per sec). The permeability to flow increases with the approach to perfect mixture which may also be expressed by saying that the loss of pressure is least for the same amount of flow. This method of separation of mixture is also of advantage from the point of view of loss of pressure. The separation of the mixture in side by side deposits of various gradings in the direction of flow gives a comparatively great permeability of flow, but in this case the flow becomes all the more unfavorable with respect to the fine particle, as the region of the grading of the total mass is more widely distributed.

Three different types of flow can be distinguished: Smooth flow, a region of transition, and a developed irregular flow, the terms "smooth flow" and "irregular flow" being used in the more general and less formal sense than the expressions "laminar" and "turbulent" flow. The relative increase of permeability to flow through separation of the mixture is, all other factors being equal, at a maximum in the first range. (Fine-grained material, small amount of flow, Fig. 7*a*.) This permeability is at a minimum in the third region. (Coarse-grained material acted upon by a swift flow, Fig. 7*b*.) The distribution of the mixture into units of the same particle size (parallel arrangement) appears to be least in the first region, Fig. 8. Irregular formation of ashes as a result of separation of the mixture of various par-

ticles occurs, therefore, in the case of fine-grained material to an entirely different extent from that which takes place with coarse-grained material, providing, however, the results are not affected by the design of the furnace.

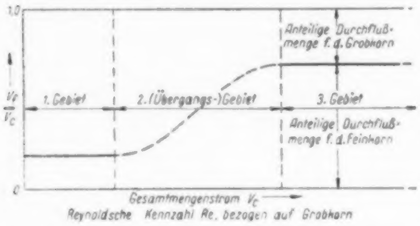


FIG. 8 DISTRIBUTION OF FLOW BETWEEN THE FINE-GRAIN AND COARSE-GRAIN, ASSUMING COMPLETE SEPARATION OF THE TWO-GRAIN MIXTURE, THIS SEPARATION BEING A FUNCTION OF THE TOTAL AMOUNT OF FLOW OR OF THE REYNOLDS COEFFICENT R_e PRESENTED DIAGRAMMATICALLY FOR A PREDETERMINED VALUE OF d_f/d_g

(V_c = total amount of flow with parallel arrangement; V_f = amount of flow through the fine-grained part of the precipitated material. *Gebiet* = range; *Übergangs-Gebiet* = transition range; *Anteilige Durchflussmenge f. d. Grobkorn* = proportion of amount of coarse-grained coal flowing through; *Anteilige Durchflussmenge f. d. Feinkorn* = proportion of the amount of fine-grained coal flowing through; *Gesamtmengenstrom* = total flow; *Reynoldsche Kennzahl* R_e *bezogen auf Grobkorn* = Reynold's coefficient R_e in terms of coarse coal.)

As regards the region of transition, the variation in the distribution of flow with the amount of flow is a characteristic feature. As the amount of flow increases the distribution becomes more uniform. From a practical point of view this brings about an easier handling of the furnace with a higher output from the furnace as indicated by the number of times the fireman has to rake the fire to produce a ton of steam. In tests with fine-grained coals of sizes from zero to 10 mm, the number of rakings decreases with increased grate output. The number of arrangements of grain sizes possible and even the number which occurs in actual practice is so great that in general the deposits must be considered not as a uniform entity but as a multiplicity of different elements. These may be best treated by static processes. (H. G. Kayser in *Die Wärme*, vol. 58, no. 35, Aug. 31, 1935, pp. 567–568, 3 figs.)

PUMPS

Water Hammer Occurring in Pump Valves

THIS is an extensive mathematical article not suitable for abstracting. Among other things, the author calls attention to the fact that there have been numerous complaints about noise produced in pumps. He has investigated the various sources of noise and has come to the conclusion that the hammer blow against the valve is seldom responsible for the noisiness. To combat this latter it is necessary to improve the suction capacity of the pump by using properly dimensioned valve cross sections. It is not possible to design a valve to sit noiselessly on its seat, since at all times the valve and water masses moving at a certain velocity, must be brought to rest when the valve closes. There is no such thing as a shockless closure. It is, however, possible by experiment to determine the velocities of closing of valves which would be accompanied by a comparatively quiet valve closure.

The author found that the hammer blow in the valve varies not with the fourth power of the number of revolutions as has been stated by O. H. Mueller, but as the square, and that the mass of the valve and water affect the blow not as its entire magnitude but only as the square root thereof. The author also points out that his experimental results are in full agreement with certain previously established equations, for example, with the Lindner equation for plate valves. (Ludwig Krauss in *Fordertechnik und Frachtverkehr*, vol. 28, nos. 23 and 24, Nov. 15, 1935, pp. 271–275)

Northey Rotary Pump

THIS pump was shown at the British Industries Fair at Birmingham. Its peculiar feature is that it is capable of producing high pressures or vacuum readings. The ability of these machines to build up a high pressure results from the fact that air is enclosed within the space swept by two approaching arms. This carries out the compression very rapidly. A seal is produced as the rotors form a definite barrier to air leaks through the valve openings. As the action of the compressor is "compounded," a two-stage effect is obtained since in its path through the compressor each particle of air must be transferred from the suction side of one arm to the compression side of the other.

From Fig. 9 it will be seen that the machine consists of a chamber formed by two intersecting cylinder bores. Within these bores two rotors revolve simultaneously in opposite directions, being carried on two parallel shafts. The shafts are coupled by equal gear wheels at one end, thus maintaining the rotors in correct relationship to each other. The rotors do not come into contact with each other or with the walls of the cylinder. Admission and delivery ports, which take the place of valves, are covered and uncovered by the rotors themselves during each revolution. As the rotors move from the position shown in Fig. 9 the space enclosed by the "trailing" sides of the arms increases and the entry of air induced via the inlet port. At the same time the area enclosed by the "advancing" sides of the arms is decreasing, and the air therein is being compressed. The end of the compression stroke is reached when the rotors have arrived at the position where the inlet arm on the lower rotor has reached the "corner" between the two bores opposite to that at which it is shown in Fig. 9. At this point most of the compressed air has been ejected via the delivery port, a small pocket, however, remaining in the space between the rotor arms. As the rotors continue to rotate from this position, the small pocket of compressed air referred to is released, and at once raises the pressure throughout the whole chamber to a value above that of the atmosphere. In

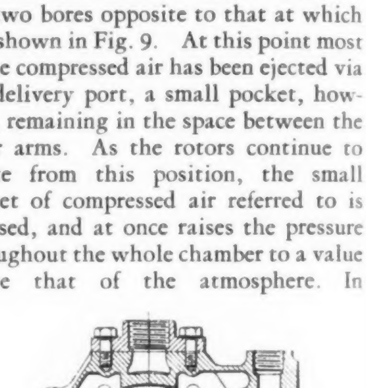


FIG. 9 SECTION OF ROTARY PUMP—NORTHEY

other words, the chamber is now supercharged. At the commencement of the succeeding revolution practically the whole of this supercharged air is on the advancing or compression side of the rotor arms. This fact insures that a full charge of new air is secured at every revolution, irrespective of the compression pressure. This supercharging effect is cumulative, so that the higher the delivery pressure attained the greater is the supercharging effect produced. (*The Engineer*, vol. 161, no. 4179, Feb. 14, 1936, p. 173, 3 figs., *d*)

STEAM ENGINEERING

Steam-Turbine Governors

IN THE 105,000-kw turboalternator at the Battersea Station of the London Power Company the main governor

is of the horizontal type. It is equipped with valves provided with spring loading above the power pistons operating the speed valves.

This enables the oil, released when the load is suddenly reduced, to be forced into a special chamber on each power cylinder, and the steam valves to be more rapidly closed than when oil pressure is employed, owing to the time lag imposed by the oil pump and the pipe friction.

The advantages claimed for this system are that the relay valves are formed in the power cylinders themselves. Interconnecting piping is thus eliminated, and rapid response to relay-valve movement is insured. The camshaft valves are also arranged immediately adjacent to the horizontal power pistons which they operate. The lift applied to the steam-valve power pistons is powerful and direct, and is free from any bending moment which might cause the valve spindle to bind in the guides. (*Engineering*, vol. 141, no. 3653, Jan. 17, 1936, serial article, pp. 53–55, illustrated)

Cantieny High-Pressure Boiler

EXPERIMENTAL work has shown that with tubes of the usual diameter employed in natural-circulation boilers the circulation of water in rising tubes subjected to high temperatures is so rapid that the coefficient of heat transmission is high enough to keep the tube-wall temperature very close to that of saturated steam. It has also been shown that damage to heated tubes occurs only in tubes where owing to some defect in circulating arrangements the water is allowed to descend. All of these problems are believed to be solved in the Cantieny boiler. In its primary form this boiler is a steam generator of the type which has a furnace cooled with tubes which generally are connected to diagonally opposed drums or headers.

The new design provides for a recirculation over the entire length of the upper drum, these recirculation tubes being naturally located outside the heating zone and an additional steam and water drum is provided with its steam space connected to the upper furnace drum by rows of tubes and its water space connected to the lower drum by tubes evenly spaced over the whole drum length. These tubes form the main feed supply to what may be conveniently described as the parallelogram system of the boiler. The discharge tubes of the collecting headers of the side-wall tube systems are also spaced over the drums. In this way the whole of the flow circuits can be coordinated and by a suitable relation between tube resistance and static head separation of steam and water takes place in the top drum of the parallelogram system; the separated water is recirculated from this drum around the system. This steam passes to the main steam and water drum suitably arranged at a higher level, from which the steam is drawn off to the superheater. The normal feed supply is also introduced into this drum in any conventional manner. The condition of throttled circulation which results in a separation of water and steam mixture in the recirculating drum and gives a discharge of substantially water-free steam makes this system particularly useful for adaptation of water cooling to the furnaces of existing boilers, in that the capacity is greatly increased while the steam generation of the boiler proper is not disturbed, and it was in this connection that the system was first developed. (*The Engineer*, vol. 161, no. 4177, Jan. 31, 1936, p. 133, 2 figs.)

Sinuflo-Tube Boiler

THE term "Sinuflo" denotes a boiler in which a sinuous tube is adopted in contradistinction to the singly curved tube often employed in boilers for constructional reasons. The majority of fire-tube boilers, as is common knowledge, have straight tubes. As the gases in such a tube flow longitudinally through it, at low speeds some do not come into contact with the tube walls and, in consequence, carry away to the chimney heat which ought to have been transmitted to the water surrounding those walls. This condition was early recognized as conducing to low thermal efficiency, and palliatives were sought in various forms of "retarder" which, inserted in the tubes, caused the gases to impinge on the tube walls. Apart from their cost and their tendency to increase the draft pressure, retarders make the internal cleaning of the tubes a long and frequent operation. The problem, then, becomes one of securing a turbulent flow inside the tube without sacrificing the structural convenience of a straight tube, or its accessibility for cleaning by brushes or other means.

A successful solution is said to have been arrived at by the employment of the Sinuflo tube in fire-tube boilers. As may be inferred from its name, this tube is formed with longitudinal "waves;" in other words, its profile in this direction is sinuous. The waves lie in one plane; that is, the tube is not "corkscrewed," and they are relatively closely pitched, the curvature of the tube being, in a sense, abrupt, and presenting a series of surfaces across the gas stream which deflect it from one side to the other. It is not claimed that the whole of the gas stream impinges on the walls of the tube; as a matter of fact there is, on looking through the tube, a clear passage, of lenticular cross section, about 0.65 the diameter of the tube in width, and having about 0.45 of the full area. This passage permits the insertion of a straight-handled brush, but does not, as might be supposed, negative the advantages of the virtual barriers across the gas stream, as the molecules in the center portion are deflected by these barriers into the more slowly-moving and cooling portions in actual contact with the tube walls, the resulting turbulence causing them to give up their heat more readily. The tube is, of course, of full cross-sectional area along its length.

The illustrations of the original article show a boiler intended for the utilization of engine exhaust gases in motor vessels. Boilers fitted with ordinary straight tubes had two passes of tubes which involved a reverse flow of the gases. With the Sinuflo tube one pass has been found sufficient. The tube nest occupies the upper half of the tube plates and consists of Sinuflo tubes 1.5 in. outside diameter. The stay tubes within the nest are of the same diameter but the nest is flanked on each side by a row of stay tubes 2 in. outside diameter. The stay tubes are straight. Performance data are cited in the original article. The Sinuflo tube may be employed also in exhaust-gas boilers of the plain-drum type on land either for steam production or water heating. Data of tests of the boiler are given in the original article. From this it would appear that the boiler has under overload working a thermal efficiency of 75.8 per cent on the gross calorific value of the coal and of 78.3 per cent on the net calorific value. (*Engineering*, vol. 161, no. 3652, Jan. 10, 1936, pp. 35–36, 3 figs.)

TESTING AND MEASUREMENT

Grindability of Coal

PREVIOUSLY a method of estimating the grindability of coal based on experimental work carried on by the Bureau of Mines has been announced. This was accepted as a tentative standard under the name of the ball-mill method. The Hardgrove method was also recommended to be accepted. This paper presents further data and includes a comparison with the Hardgrove method, and data of tests of runs which were made with another procedure recently proposed, namely, C.I.T. roll-test method.

In the ball-mill method the relative amounts of energy necessary to grind coals to the same fineness are determined by the number of revolutions of the mill required to reduce 80 per cent of the feed (500 grams of 10- to 200-mesh coal) fine enough to pass a 200-mesh screen. This is a somewhat finer size than that commonly used for pulverized-coal firing. The finished product is removed in increments of 10 per cent by stopping the mill and screening out the undersize at the end of each cycle. This prevents overgrinding, maintains a more constant size distribution in the subsieve material, and simulates the continuous removal practiced industrially.

In the Hardgrove-machine method, 50 grams of coal, sized between 14- and 28-mesh (Tyler) sieves, is ground in a special ring-and-ball machine for 60 revolutions. The resulting product, in which the amount of new surface is estimated from a screen analysis, is considerably coarser than a pulverized fuel.

The difference in the principles by which these two methods measure grindability is of particular importance. The ball-mill method is the only one so far proposed in which the relative amount of work required to grind coal to pulverized-fuel size is determined. By all other methods an equal amount of work is performed on each sample and the relative grindability obtained by estimating the new surface produced. Such procedures, although they may be reproducible, are subject to the limitation that by far the greater amount of surface is concentrated in the subsieve size; that is the sizes that are finer than the finest sieves available. The approximation of surface in subsieve coal is an exacting and time-consuming task. Consequently, methods specifying a constant amount of work apply the same assumed mean size to the subsieve material from any and all coals. In order to test the validity of this assumed constant mean-size value, and to determine the effectiveness of stage removal in the ball-mill method, a study was made of the subsieve material obtained by testing three coals by both methods.

The C.I.T. method was described in the Transactions, A.S.M.E., 1934, vol. 56, pp. 773–779. Briefly, in this method a sample of sized coal placed on a flat steel plate is crushed by rolling a heavy steel cylinder over it ten times. The crushed product is then screen-sized and the new surface produced is calculated from the screen analysis. In principle the method may be characterized as belonging to the class of constant-work methods such as the Hardgrove and is subject to the same criticisms. The C.I.T. method has been carefully tested and the results of application to five different coals given in the original paper.

The investigation showed that coals are mixtures of components, each of which requires a different amount of energy to grind. Relative grindability results cannot be accurate unless equal proportions of these components are ground to the size suitable for use as powdered fuel. This is accomplished by the ball-mill procedure, but not by either of the constant-work methods. With the latter type only the less resistant or softer components are ground; consequently the relative grindability values obtained do not represent accurately the grindability of the total sample. (Paper before A.I.M.E., presented at meeting of February, 1936, by H. F. Yancey and M. R. Geer, 17 pp., 1 fig.)

WELDING

Welding by Electrodeposited Iron

THE present paper deals with the manufacture of composite steels as well as piece-to-piece welding, and describes the Armstrong method used by the author's company. In this method the alloy steel is first given an electrolytic coating of pure iron. If the electrolytic iron is properly deposited upon the alloy steel it will bond there by diffusion upon the application of heat alone. This pure electrolytic iron with the alloy steel behind it can then be welded easily by heat and pressure to any other piece of iron or to another piece of alloy steel that has been given a similar coating of electrolytic iron. It is claimed that the Armstrong method of electrodepositing iron upon alloy steels employs a special technique partly described in the original article and that it causes the iron plating to adhere to the base metal and to make a permanent bond by diffusion when heated to a red heat, preferably about 1700 F.

Data on assembling of composite billets are given in the original article. The two or more pieces that go to make up a composite billet are assembled in various ways, depending upon the position and amount of the alloy steel required in the finished product, but each component piece is pressed firmly against its neighbor in a vise provided with powerful jacks and then welded together by electric arc. It must be emphasized that this electric-arc welding has no part in the heat-pressure welding to take place in the composite billet, other than to hold the pieces together and prevent scaling away of the electrolytic iron while the composite billet is being heated for forging or rolling. The electric-arc weld will always be ground away before finish rolling, except on plates from which trimming of the finished product will remove it.

Forging or rolling of the composite billet produces a perfect weld. The temperature used is that demanded by the steel in the assembly that requires the highest temperature for good hot-working qualities. Warping and twisting of the composite billet due to unequal coefficients of expansion are always encountered once the perfect weld has been made, and must be overcome either by using double assemblies or by the use of special guides. Where there is a great difference in hot-work ductility between the components, special rolls and guides must be made to guard against flow of the more ductile metal around the less ductile one.

Sheets rolled on a plate mill are free from both of these troubles if the sheets are assembled and rolled two high. Normal trimming of the sheet removes all material that may flow around the edges.

It is worthy of notice that where a perfect weld is produced a steel such as high-speed steel will elongate during rolling almost as much as the softer backing material. The roll pressure on the bar as it passes through the rolls is vertically downward, and if the weld is perfect so that there can be no slip, the two kinds of steel must elongate together. Sideways spread of the softer metal is a different problem, and is overcome only by special grooves in the rolls. The original article gives illustrations of some of the shapes and positions of insert that can be produced with finished material and the composite billet necessary at the start. Data as to the properties of the material produced are given in the original article.

The three important features of finished welds made by this method are: (1) The weld zone is free from nonmetallic matter; (2) the weld zone can be heat-treated in the same way as an alloy steel; and (3) the weld zone is strong and tough: a graduated alloy steel from the facing metal on the one side to the backing metal on the other side.

This method of welding is applicable to many nonferrous metals, and alloys such as Stellite and Hastelloy, which by its use have been successfully welded to iron-backing material. (Leonard C. Grimshaw, in a paper before the February, 1936, meeting of the A.I.M.E., Technical Publication No. 667, 20 pp., 24 figs.)

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers, A.S.M.E. Activities

Thin-Plate Orifices

To the Editor:

During 1935, the following engineers have published material on thin-plate orifice-plate meters that bears on the effect of distortion of the plate: The closure by Tuve and Sprenkle of their 1933 A.S.M.E. paper on "Orifice Coefficients for Viscous Liquids;" Ronald B. Smith, in his discussion of this paper gave a theoretical treatment showing large errors due to minute "oil-can bottom"

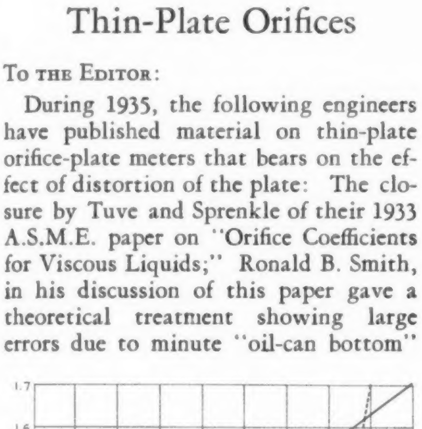


FIG. 1 CORRECTION CURVE FOR VELOCITY OF APPROACH

deformations of the plate; Howard E. Bean, in the A.G.A. *Journal*, discussing the peculiar performance noted by Witte on testing steam orifices, concluded that there was a discrepancy of roughly one per cent between data on steam and water tests, which discrepancy Bean used in attempting to reconcile such American data; and L. S. Marks, in metering air to blowers, chose to use orifices having slight conicity instead of the conventional flat orifice.

Does the usual monel orifice plate deform like an oil-can bottom, when clamped between iron flanges, and heated and acted upon by a differential pressure due to steam flow? If so, the performance of a steel orifice between steel flanges, or with the orifice so mounted as to be free to expand without deformation, should be investigated. (In any case, the serious errors theoretically existing, with only slight "dishing" of the orifice plate noted by R. B. Smith, and earlier by Swift, should be checked experimentally.) In view of the large number of such steam meters, this question should be settled experimentally.

In his 1902 paper on nozzles and orifices for hot water, Rateau remarked in regard to expansion errors that "it would be advantageous to employ metals having a very small coefficient of expansion, such as the new alloys of iron and nickel."

The accuracy of measurement of 3 per cent, or more, wet steam by venturis, nozzles, and orifices also deserves investigation as a related matter.

Engineers interested in flow meters may find convenient the nearly straight-line relation between $d_1/(d_1 - d_2)$ and the correction for velocity of approach

$$1/\sqrt{1 - (d_2/d_1)^4}$$

where d_1 and d_2 are, respectively, the pipe and orifice diameters, Fig. 1. This relation was used by the writer during 1935 in interpolating to obtain the correction with large diameter ratios more accurately than is conveniently possible upon the usual basis of d_2/d_1.

Ed S. Smith, Jr.[1]

Steam Automotive Plant

To the Editor:

What Mr. Prescott[2] says about steam cars of the past is, on the whole, true. We believe, however, that some mention should be made of the modern steam car and of the elimination of the drawbacks to which he refers in the first paragraph of the article. Great progress has been made in the steam vehicle and in view of it we believe it unfair and unnecessary to judge it by the productions of 20 years ago. It is true that the latter were eliminated in open competition, but the steamer is in the process of staging a comeback and in its up-to-date form it is steadily gaining ground.

The fire hazard with a modern steam car is less than with other cars because of the use of nonexplosive (and also nonpoisonous) fuel. There is no pilot light, ignition being electric and combustion being effected with a household type of oil burner. There is no exposed flame at any time. The "delay" in starting from cold has been reduced from about twenty minutes to about three, a time little, if any, in excess of that required to get a gasoline car warmed up and operating properly. The car is started by turning on a switch. The power plant is controlled automatically, so that the driver's only concern is to drive the car. The latter operation is extremely simple owing to the elimination of the gear shift and clutch. Although a high degree of mechanical ability is useful in the operation of any car, only an extremely small percentage of steam cars are owned by engineers or mechanics with any greater mechanical ability than is usually possessed by the average motorist.

The successful adaptation by the Besler brothers a few years ago of a steam plant to a Travelair biplane deserves mention as being something more than a "serious attempt." The condenser requirements are by no means prohibitive because the conditions for condensation aboard an airplane in flight are practically ideal, and it should be comparatively simple to effect at least 99 per cent recovery. The fuel weight is no greater than with a gas engine, while the weight of the power plant can be considerably reduced over the trial set-up used by the Beslers, particularly if it is given anywhere near the development that has been put into the gas engine. An important consideration is the fact that a steam plant requires only one third (or less) as many cylinders as an internal-combustion engine. The reduction of the fire hazard owing to the use of low-grade fuel, the durability and low upkeep cost of a steam plant, and the quiet, vibrationless action of steam power, seem, in our opinion, to place the steam engine definitely in the running as a military (and other) aircraft engine of the future.

G. Stevenson.[3]

[1] Hydraulic Engineer, Builders Iron Foundry, Providence, R. I. Mem. A.S.M.E.

[2] "Military Aircraft Engines of the Future," by Ford L. Prescott, Mechanical Engineering, March, 1935, pp. 157–161.

[3] Assistant General Sales Manager, American Steam Automobile Co., Newton, Mass.

The Social-Credit Concept

To the Editor:

May I suggest, after a careful reading of E. R. Livernash's article[4] on "The 'Social-Credit' Concept," which, parenthetically, does not mention the Social Credit concept,' that to demolish any argument it is necessary (1) to be familiar with it, and (2) to present it clearly and correctly so that the spectator as well as the critic may see the incidence of criticism?

Major Douglas' arguments are no exception to this rule. If they can be demolished, they ought to be, and as quickly and completely as possible. If not, they should be exempt, particularly in scientific periodicals, from treatment which merely confuses the public mind about them. Nobody, perhaps, knows better than an engineer how prone the human mind is to confusion, even when it is left free to come to correct conclusions if it can. But the present state of the world is one in which confusion concerning important matters is a diabolical nuisance and to foster it an invitation to disaster.

(1) The phrase "purchasing power" in regard to goods means the power to buy goods. The possession of money bestows purchasing power in regard to purchasable priced goods; but this is not to say that purchasing power and money are "synonymous terms," or that the unconfused and uncontaminated phrase "purchasing power" is "meaningless" unless in the sense that the public does not at present possess the real equivalent.

(2) Major Douglas' "Draft Social-Credit Scheme for Scotland" is brief enough to have escaped condensation. There is stated in its first paragraph the nature of the real capital assets of the people of Scotland. The "arbitrary" figure of one per cent "for the purpose of initial stages" ought to be a sufficiently conservative estimate of productive power unless bank rates are fantastically high—which is, I fancy, no more Mr. Livernash's belief than it is mine. If the world's bankers assess the productive power of existing capital higher than one per cent the world's bankers should be the first to concur in the distribution of a dividend in money more closely approximating to their assessment of the prices to be liquidated. After all, it is they who will receive the money in the end; and if they are impatient for the repayment of their loans, surely the more money passing up to them through the industrial system the better? Or isn't it?

Claiming that it is "apparent" to him that producers' profits would be increased through increased volume of business, i.e., more goods sold, i.e., bought, despite reduction of wage *costs*, Mr. Livernash slips in a phrase familiar in "the fundamental assumptions of economic theory," the phrase "with the maintenance of prices at the old level." Why should prices be maintained at their old level if provision is made for discounting them? The level proposed to be maintained is the much more important level rate of profit on turnover.

(3) Mr. Livernash complains that, like the dividend rate, the discount rate, simultaneously operating, is "arbitrary." Major Douglas said "a *suitable* value of this for initial purposes" would be 25 per cent; but it "might reasonably be higher." Why not? The initial purpose being met, there is explicit provision for the precise determination of the rate of discount *effective* to remove goods from the market without financial loss to any one.

(4) It is said that the "antithesis" between the receipt of goods and the receipt of permission to expend energy in work for wages is "at variance with the fundamental assumptions of economic theory." Does this mean that the assumptions of economic theory assume income and expenditure to be the same thing? Major Douglas has said so persistently, and a note at the end of the "Scheme for Scotland" repeats it: "Money and real assets are on opposite sides of the account (and should balance) not, as in a commercial account, on the same side of the account."

(5) The "heart of Major Douglas' argument" having eluded Mr. Livernash—it is the Social Credit concept, which he does not explore—Mr. Livernash finds it in the still undemolished truism that costs (and therefore prices) mount quicker than the means available to the community to cancel them without recourse to borrowing. At this point Mr. Livernash exhibits curiosity concerning collective prices. He says the prices of raw materials, machinery, etc., "are of no direct concern to consumers." Then why should they be asked to meet them? And, alternatively, if they don't, who should and how? But since Mr. Livernash is himself satisfied with "it seems to be" as an answer to the question whether the cost of industry is self-liquidating, one may retort that it does *not* seem to be; but judged by every resultant test it obviously is not, and that all that Major Douglas' arguments have suffered at your contributor's hands is the impact of an ill-informed adverse opinion.

TUDOR JONES.[5]

Foundations of Marxism

To the Editor:

Does the publication of "Foundations of Marxism," in the July, 1935, MECHANICAL ENGINEERING (pp. 434–435) mean that the engineer is going Marxist? That was the shocking reaction I received while reading Harold A. Freeman's review on the "Nature of Capitalist Crisis" by John Strachey. But after recalling Lincoln's legal procedure, it would seem that these negative reactions are to our detriment and not to our advancement. Perhaps a better approach to the breakdown of these "isms" would be to study them intently for a fuller preparation in an intelligent combat against the "ism" of one's choice. It seems difficult to understand how one can counteract or approve an economic system opposed to the American institutional system with uninformed and ignorant babblings. Therefore, it seems that a careful perusal of good books on other economic orders, opposed to the American system, are worthy of consideration and a *brief* presentation in this journal.

E. DILLON SMITH.[6]

[4] MECHANICAL ENGINEERING, vol. 58, January, 1936, pp. 35–36.

[5] Social Credit Secretariat Limited, London, England.

[6] School of Science and Technology, Pratt Institute, Brooklyn, N. Y. Jun. A.S.M.E.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following are records of the interpretations of this Committee formulated at the meeting of February 28, 1936, and approved by the Council.

CASE NO. 817

(Special Rule)

Inquiry: When the shells of vessels are fabricated by riveting or brazing but a short distance at the ends of the longitudinal seams, or abutting edges of shells and butt straps, are welded by qualified welding operators, is it the intent of the Committee that such vessels shall be classified as welded vessels and stamped with the welding paragraph number as provided in Par. U-66?

Reply: It is the opinion of the Committee that if the welding as described is in accordance with the welding requirements of the Code for qualified welding operators and the welding at the ends of a longitudinal seam does not extend for a distance greater than $4t$ (t = shell thickness) from the edge of the flange of the head, the vessel need not be stamped with the paragraph number as provided in Par. U-66.

CASE NO. 819

(Special Rule)

Inquiry: Is it permissible, in the manufacture of fusion-welded power-boiler drums, to use steel similar to that covered by Specifications S-26 and S-27, except that the carbon content is limited to 0.25 per cent maximum, and molybdenum is added within a range of from 0.25 to 0.60 per cent for S-26 steel and 0.40 to 0.60 per cent for S-27 steel?

Reply: It is the opinion of the Committee that the material specified in the inquiry will meet Code requirements when used in the manufacture of fusion-welded boiler drums.

Revisions and Addenda to Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as proposed addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from any one interested therein. It is to be noted that a proposed revision of the Code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PARS. P-12*b* and *c*. Revise to read as follows:

b Cast-iron . . . . may be used for boiler and superheater connections under pressure, such as pipes, fittings, WATER COLUMNS, valves, and their bonnets . . . .

c Malleable iron . . . . may be used for boiler and superheater connections under pressure, such as pipes, fittings, WATER COLUMNS, valves, and their bonnets . . . .

Table P-7$^1/_2$ (U-3$^1/_2$). In the form that this table appears in the January, 1936, issue of MECHANICAL ENGINEERING revise the heading of the five columns of S values to read: "For METAL temperatures not exceeding deg F."

Revise temperature of "400*" to read "406," and omit footnote to table.

PARS. P-103*b* and U-71*b*. Revise to read:

b Material for manhole frames, nozzles and other pressure connections which are to be joined to the shell or heads by fusion welding shall, when forged or rolled, comply with the specifications given for [shell] plates [and heads] OR FOR FORGINGS as to chemical and physical properties and be of good weldable quality. Cast[ings] steel OR WROUGHT STEEL [and commercial] nozzles may be used only when the material has been proved to be of good weldable quality. THE CARBON CONTENT IN ALL SUCH MATERIAL SHALL NOT EXCEED 0.35 PER CENT.

PAR. P-110. Revise to read:

P-110 *Inspection.* THE MANUFACTURER SHALL SUBMIT THE DRUM FOR INSPECTION AT SUCH STAGES OF THE WORK AS MAY BE DESIGNATED BY THE INSPECTOR. [The inspector may designate stages of the work at which he wishes to inspect the welded joints and the manufacturer shall either submit the drum for inspection in such partly completed condition, or as an alternative he may permit the inspector to witness stages of the welding operation at such times as the inspector may select.]

PARS. P-198 and U-39. Revise the definitions of c and j to read:

$C = 0.30$ for flanged plates attached to vessels as shown in Fig. U-2*c* by means of circumferential lap joints, riveted, fusion welded, or brazed and meeting all the requirements therefor, and where the corner radius on the inside is not less than 3 times the thickness of the flange immediately adjacent thereto. A FLANGED HEAD MAY BE SCREWED ON THE END OF A VESSEL, IN WHICH CASE FAILURE BY SHEAR, TENSION OR COMPRESSION, DUE TO THE HYDROSTATIC END FORCE, SHALL BE RESISTED WITH A FACTOR OF SAFETY OF AT LEAST 5. SEAL WELDING MAY BE USED IF DESIRED.

$C = 0.75$ for plates screwed into the end of a vessel having an inside diameter d not exceeding 12 in., as shown in Fig. U-22*j*, OR FOR PLATES HAVING AN INTEGRAL FLANGE SCREWED OVER THE END OF A VESSEL HAVING AN INSIDE DIAMETER d NOT EXCEEDING 12 IN., where the hydrostatic end pressure on the head is resisted with a factor of safety of 5 both by the threads engaging the flat head and the vessel wall and by the reduced cross section of the threaded portion of the vessel OR HEAD FLANGE, AS THE CASE MAY BE. Seal welding may be used, if desired.

PAR. P-216. Revise the second sentence to read:

ANY [that] part of the tube sheet which comes between the tubes, or cylindrical furnace, and the shell, etc.

PAR. P-268*a* and U-59*b*. Revise third section under "Threaded Connections" to read:

When the maximum allowable working pressure exceeds 100 lb per sq in. (125 lb in Par. U-59*b*) threaded joints FOR NIPPLE OR PIPE CONNECTIONS over 3 in. pipe size, shall not be used either at the shell or terminating end of

such connections. WHEN THREADED JOINTS ARE USED FOR OTHER PURPOSES SUCH AS INSPECTION OPENINGS OR END CLOSURES, THE FOREGOING LIMITATION OF 3 IN. PIPE SIZE SHALL NOT APPLY, BUT THE DETAILS OF SUCH CONSTRUCTION MUST MEET THE REQUIREMENTS OF OTHER SECTIONS OF THE CODE WHERE THREADED JOINTS ARE PERMITTED.

PARS. P-268*a* and U-59*b*. Insert the following as the seventh section of Par. P-268*a:*

Piping connected to the flanges of outlet nozzles on the boiler shell or superheater headers, or for piping between pressure parts of the boiler, may be attached by any of the methods given in Par. P-300.

and as the fourth section of Par. U-59*b:*

Piping connected to the flanges of outlet nozzles on a pressure vessel, or for piping between pressure parts of a pressure vessel may be attached by any of the following methods: (1) by screwing into a tapped opening with a screwed fitting or valve at the other end, (2) by screwing each end into tapped flanges, fittings, or valves with or without rolling or peening, (3) by bolted joints including those of the Van Stone type, (4) by expanding into grooved holes, seal welding if desired.

PAR. P-299. Revise the fifth section to read:

All valves and fittings on FEEDWATER PIPING AND WATER PIPING [water lines] below the water line shall be equal at least to the requirements of the American Standards, etc.

PAR. P-301. Modify the proposed revision of the second sentence appearing in the April, 1936, issue of MECHANICAL ENGINEERING to read:

When such outlets are over 2-in. pipe size, the valve or valves used on the connection shall be of the outside-screw-and-yoke rising-spindle type so as to indicate AT A DISTANCE by the position of its spindle whether it is closed or open and the wheel may be carried either on the yoke or attached to the spindle. A PLUG COCK TYPE VALVE MAY BE USED PROVIDED THE PLUG IS HELD IN PLACE BY A GUARD OR GLAND, AND IT IS EQUIPPED TO INDICATE AT A DISTANCE WHETHER IT IS CLOSED OR OPEN AND IT IS EQUIPPED WITH A SLOW-OPENING MECHANISM.

PAR. P-311. Revise to read:

P-311 *a* On all boilers except those used for traction and/or portable purposes, when the allowable working pressure exceeds 100 lb per sq in., each bottom blow-off pipe shall have two slow-opening valves, or one slow-opening valve and a QUICK-OPENING VALVE OR A cock complying with the requirements of Par. P-310.

By slow-opening valve is meant one which requires at least five 360 deg turns of the operating mechanism to change from full-closed to full-opening and vice versa.

On a boiler having multiple blow-off pipes, a single master valve may be placed on the common blow-off pipe from the boiler, in which case only one valve on each individual blow-off is required. IN THIS CASE EITHER THE MASTER VALVE OR THE INDIVIDUAL VALVES OR COCKS MUST BE OF THE SLOW-OPENING TYPE.

Two independent SLOW-OPENING valves or a SLOW-OPENING valve and a QUICK-OPENING VALVE OR A cock may be combined in one body provided the combined fitting is the equivalent of two independent SLOW-OPENING valves or a SLOW-OPENING valve and a QUICK-OPENING VALVE OR A cock so that the failure of one to operate could not affect the operation of the other.

The drain or blow-off valves for water walls or other screens forming parts of a boiler shall conform to the requirements of this paragraph and also of Pars. P-308 AND P-309.

b The bottom blow-off pipes of every traction and/or portable boiler shall have at least one SLOW OR QUICK-OPENING blow-off valve OR COCK conforming to the requirements of Par. P-310.

PAR. P-327. Add the following:

THE BONNET OR SMOKE HOOD OF A VERTICAL FLUE OR TUBULAR BOILER SHALL BE PROVIDED WITH AN ACCESS OPENING AT LEAST 6 × 8 IN. FOR THE PURPOSE OF INSPECTION AND CLEANING THE TOP HEAD OF THE BOILER.

Specifications S-1. To make these specifications identical with A.S.T.M. Specifications A-30-35T, Pars. 1, 3, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16 will be revised, and a new Par. 3 will be inserted on Heat Treatment. Also, revise title to read:

"Specifications for Carbon-Steel Plate for Boilers and Other Pressure Vessels."

Specification S-11 (Based on A.S.T.M. Specifications A 27-36T) Revise this specification to read as follows:

1 *Scope.* These specifications cover five grades of castings suitable for fusion welding: namely,

Grade A-2, Castings of this grade as specified by the purchaser, required to be annealed and to be physically tested.

Grade A-3, Castings of this grade as specified by the purchaser, required to be full annealed and to be physically tested.

Grade *B*, Castings of this grade as specified by the purchaser, required to be annealed and to be physically tested.

Grade *B*-1, Castings of this grade as specified by the purchaser, required to be full annealed and to be physically tested.

Grade *B*-2, Castings of this grade as specified by the purchaser, required to be full annealed and to be physically tested.

2 *Process.* The steel shall be made by one or more of the following processes: open-hearth, electric-furnace, or crucible.

3 *Heat Treatment. a* The heat treatment either by normalizing or by full annealing at the option of the manufacturer, shall be applied to all castings of Grade A-2. A full annealing treatment shall be applied to all castings of Grades A-3, B, B-1 and B-2. Unless otherwise specified, all castings may be annealed one or more times (Note 1).

b All those castings that are to be heat-treated in any manner shall have been allowed to cool after pouring, to a temperature below the critical range.

c Normalizing. The procedure for normalizing shall consist of heating the castings to the proper temperature above the critical range for the required time as a preliminary procedure for the ultimate refinement of the grain, and cooling in still air at room temperature (Note 2).

4 *Temperature Control.* Furnace temperatures for heat treating shall be controlled effectively by pyrometers.

5 *Chemical Composition.* Steel used for the castings shall conform to the following requirements as to chemical composition:

Manganese, max., per cent	1.00
Phosphorus, max., per cent	0.05
Sulphur, max., per cent	0.06
Carbon, max., per cent	0.35

6 *Ladle Analysis.* An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, silicon, phosphorous, and sulphur. This analysis shall be made from drillings taken at least 1/4 in. beneath the surface of a test ingot made during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Par. 5.

7 *Check Analysis.* An analysis may be made by the purchaser from a broken tension test specimen or from a casting representing any melt. The chemical composition thus determined shall conform to the requirements specified in Par. 5. Drillings for analysis shall be taken at least 1/4 in. beneath the surface, and in such manner as not to impair the usefulness of any casting selected for such check analysis.

8 *Tension Tests. a* The tensile properties of steel used for castings of the grades that require physical testing shall be determined from the required number of specimens having a 2-in. gage length, conforming to the dimensions shown in Fig. 1.

b One or more coupons sufficient in size and number to provide the required test specimens shall be cast separately or attached to one or more castings of the kind ordered by the purchaser, in each melt used for manufacture of the purchased material (Note 3). Unless otherwise specified or agreed to between the purchaser and the manufacturer, the test coupons shall be designed by the manufacturer and may be cast separately (Note 4).

c Steel used for the castings shall conform to the following minimum requirements as to tensile properties (see top of page 323):

d The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine, or by an extensometer, at a cross-head speed not to exceed 1/8 in. per minute. The tensile strength shall be determined at a speed of head not to exceed 1 1/2 in. per minute.

9 *Test Specimens. a* Such physical test coupons as may have been connected directly or by runners to commercial castings (Par. 8*b*) shall remain so attached until the material is submitted for inspection. All physical test coupons shall be heat treated with the castings represented by them unless the purchaser authorizes separate heat treatment. Test coupons shall be provided by the manufacturer without extra charge in sufficient number to furnish specimens for all tests, except as other-

	Tensile strength, lb per sq in.	Yield point, lb per sq in.	Elongation in 2 in., per cent	Reduction of area, per cent
Grade A-2, Normalized*...........	60,000	30,000	26	38
Grade A-3, Full Annealed..........	60,000	30,000	24	35
Grade B, Normalized*.............	70,000	38,000	24	36
Grade B-1, Full Annealed..........	66,000	33,000	22	33
Grade B-2, Full Annealed..........	70,000	35,00C	20	30

* Any castings that may be ordered to meet the tensile requirements above listed for normalized material of Grade A-2 may, at the option of the manufacturer, be given a full annealing treatment instead of a normalizing treatment; provided that the above listed tensile requirements for normalized material are met.

wise agreed to between the purchaser and the manufacturer.

b If agreed to between the manufacturer and the purchaser's inspector, tension-test specimens may be taken from commercial castings instead of from special coupons.

c Tension-test specimens shall be machined by the manufacturer and shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

10 *Number of Tests*. *a* One tension test shall be made from each melt in each heat treatment charge.

b If any test specimen shows defective machining or develops flaws, it may be discarded, in which case another specimen from the same lot[1] shall be substituted.

11 *Retests*. *a* If the results of the physical test for any lot[1] do not conform to the requirements specified, the manufacturer may reheat treat such lot, but not more than twice. The results of acceptable retests shall conform to the requirements specified in Par. 8*c*.

b If the percentage of elongation of any tension test specimen is less than that specified in Par. 8, and any part of the fracture is more than $^3/_4$ in. from the center of the gage length as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

12 *Workmanship*. All castings shall be made in a workmanlike manner and shall conform substantially to the dimensions on drawings furnished by the purchaser before manufacture is started; or to the dimensions predicated by the pattern supplied by the purchaser, if no drawing has been provided.

13 *Finish*. *a* The castings shall be free from injurious defects, and shall be satisfactorily cleaned for their intended use when offered for inspection.

b Minor defects that will not ultimately impair the strength of the castings may, with the consent of the purchaser's inspector, be welded by an approved process. The defects shall first be cleaned out to solid metal, and after the castings are welded they shall be heat treated, if required by the purchaser's inspector.

14 *Marking*. The manufacturer's name or identification mark and the pattern number, also the purchaser's identification marks when specified shall be cast on all castings excepting those of such small size as to make such marking impracticable. In addition, the numbers of the melts used for pouring the castings shall be stamped on all castings individually weighing 300 lb or more. The locations and sizes of cast identification marks shall be as agreed upon between the manufacturer and the purchaser's inspector (Note 5).

15 *Inspection*. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

16 *Rejection*. *a* Unless otherwise specified, any rejection based on tests made in accordance with these specifications shall be reported within five working days from the receipt of samples.

b Material which shows injurious defects following original inspection and acceptance at the manufacturer's works shall be rejected. The manufacturer shall be notified promptly of such rejection.

17 *Rehearing*. Tested samples representing rejected material shall be held for 14 days from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

NOTES REGARDING SELECTION AND CHARACTERISTICS OF GRADES

Grades A-2 and A-3 are produced intentionally with such low carbon contents as to make the material very soft and machinable with great ease, either in the "as-cast," normalized, or full annealed condition. The carbon contents commonly found in these grades effectively adapt them for fusion fabrication with such wrought parts as often are made of low carbon-steel.

Grade B (normalized) is used in making a great many carbon-steel castings purchased for miscellaneous industrial applications.

Grade B-1 (full-annealed) and Grade B-2 (full-annealed) are used often for castings whose intended use and/or member-thickness cause the purchasers or manufacturers to prefer a full-annealing treatment for the development of desired physical properties and for the prevention of any stresses that might be induced by the cooling operation that is incidental to normalizing. Grades B, B-1, and B-2 are easily machined with ordinary machine tools.

The tensile requirements for the full-annealed grades that are specified herein can be met by specimens made from test coupons of customary proportions, cast separately or attached in any manner to commercial castings of any size, after a full-annealing treatment of proper time-cycle for the material purchased.

Specifications S-26. To make these specifications identical with A.S.T.M. Specifications A 149-35T, the following paragraphs

[1] The term "lot" as used in this paragraph means all castings from each melt in each heat-treatment charge.

NOTE 1. According to current, officially accepted definitions, the term "heat treatment" covers any method of intentionally and systematically applying heat at a temperature below the melting point, to a metal after it has cooled following pouring. Consequently the term now is used without regard to whether such heat is applied one or more times, and irrespective of the cooling procedure. The term "annealing" is authoritatively intended to cover either "normalizing" (air cooling) or "full annealing" (furnace cooling).

NOTE 2. The proper time for holding or "soaking" many castings of moderate thickness at maximum temperature in the heat treating furnace is believed by many persons to be one hour per inch of thickness of the heaviest member.

NOTE 3. The direct attachment of test coupons for their entire length and width to commercial castings of certain designs is inadvisable, even when the castings are sufficiently large to permit such attachment. A test coupon may be so formed and attached as to "bleed" the connected casting, thereby forming a solid coupon while injuring a member which may function largely as a feeding head for the coupon. The attachment of test coupons to commercial castings by means of runners is not open to the objection cited.

NOTE 4. The special test block conventionally used in many steel foundries, frequently called a "keel-block," consists of a slab or plate having a small area and one or more underlying ribs. The slab or upper portion is made sufficiently thick to properly feed the ribs or coupons, which often are approximately 1 in. thick. Specimens from coupons made uniformly in some such manner afford reliable means for making accurate comparative evaluations of steel used for casting manufacture.

Higher combinations of physical properties than those specified herein are obtained in testing specimens from coupons on conventional test blocks, when the coupons are liquid quenched and subsequently tempered or drawn.

NOTE 5. The resistance of a sand mold to the erosive effect of inflowing metal is aided by smooth mold surfaces. Cast identification marks are formed by making indentations on the fact of the mold. For the prevention of small defects caused by dislodged particles of molding sand there should be provided the minimum feasible number of cast identification marks.

will be revised: Pars. 1, 3 (Omit), Pars. 4, 7*a* and *b*, 8, 9, 10*a*, 11, 15.

Specifications S-27. To make these specifications identical with A.S.T.M. Specifications A 150-35T, the following paragraphs will be revised: Pars. 1, 3, 8, 11, 13. Also, revised title to read:

"Specifications for High Tensile Strength Carbon-Steel Plates for Fusion-Welded Pressure Vessels (Plates Over 2-In. to 4-In. Inclusive in Thickness.)"

Specifications for Electric-Resistance Welded Steel and Open-Hearth Boiler Tubes. A.S.T.M. Specification for Electric-Resistance-Welded Steel and Open-Hearth Iron Boiler Tubes (A 178-35T) has been adopted for incorporation in the Material Specifications Section of the Code.

Specifications for Alloy-Steel Castings for Valves, Flanges, and Fittings for Service at Temperatures from 750 to 1100 F (A.S.T.M. Specification A 157-35T), Specifications for Seamless Alloy-Steel Pipe for Service at Temperatures from 750 to 1100 F (A.S.T.M. Specification A 158-35T), and Specifications for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for Service at Temperatures from 750 to 1100 F (A.S.T.M. Specification A 182-35T). These three specifications have been adopted for incorporation in the Code.

PAR. A-11. Delete.

PAR. A-13. Omit the second and third sections which read:

A $3^1/_2$-in. bevel-seated valve with 0.11-in. lift would discharge in heat units $U = 161{,}000 \times 239.7 \times 3^1/_2 \times 0.11 = 14{,}858{,}000$, and in weight of steam $W = 110 \times 239.7 \times 3^1/_2 \times 0.11 = 10{,}150$.

From which it can be seen that either method indicates that two such valves will give the proper relieving capacity.

PAR. A-14. Omit the second section which reads:

A bevel-seated $3^1/_2$-in. valve with 0.11-in. lift has a discharge capacity at 100-lb pressure of 4840 lb; hence two such valves would be required.

PAR. A-15. Omit the second section which reads:

A bevel-seated $2^1/_2$-in. valve with 0.08-in. lift has a discharge capacity at 275-lb pressure of 6350 lb; hence two such valves would be required.

PAR. A-16. Omit the second section which reads:

A bevel-seated 2-in. valve with 0.07-in. lift has a discharge capacity at 150-lb pressure of 2500 lb; hence one such valve would be required.

PARS. A-44*b* and P-275*b*. Change reference at end of section to read:

See Appendix, Pars. A-12 [A-11] to A-17.

PAR. L-29. Revise first sentence to read:

The ultimate strength of a joint THAT [which] has been properly welded by the forging process shall be taken AT [as] 35,000 [28,500] lb per sq in., with steel plates MANUFACTURED IN ACCORDANCE WITH SPECIFICATION S-2 [having a range in tensile strength of 45,000 to 55,000 lb per sq in.]

PAR. H-28. Revise fourth section to read:

[The minimum size of] A firedoor OR OTHER ACCESS opening [in an internally fired boiler in which the minimum furnace dimension is 24 in. or over shall] not [be] less than 11 by 15 in., or 10 by 16 in., OR 15 IN. IN DIAMETER [size] SHALL BE PROVIDED FOR THE FURNACE OF AN INTERNALLY FIRED BOILER IN WHICH THE LEAST FURNACE DIMENSION IS 28 IN. OR OVER. [A circular opening shall not be less than 15 in. in diameter.]

PAR. U-2 and Preamble to Power Boiler Code. Insert the following as the second section of Par. U-2 to the Preamble to the Power Boiler Code and add:

An unfired pressure vessel which generates steam for power or heat to be used externally to itself shall be classed as an unfired steam boiler. Such vessels may be constructed under the appropriate classification of the Unfired Pressure Vessel Code and shall be equipped with the safety devices required by the Power Boiler Code in so far as they are applicable to the service of the particular installation.

PAR. U-69. Revise first sentence to read:

All vessels covered by this code when constructed in accordance with the rules of this paragraph may be used for any purpose . . . . provided the plate thickness OF SHELLS AND OF HEADS FABRICATED OF MORE THAN ONE PIECE does not exceed $1^1/_2$ in., and the maximum pressure does not exceed 400 lb per sq in., nor at a temperature in excess of 700 F. THE LIMITATION OF PLATE THICKNESS DOES NOT APPLY TO HEADS FORMED OF A SINGLE PLATE.

PAR. U-70. Revise second sentence to read:

THE plate thickness OF SHELLS AND OF HEADS FABRICATED OF MORE THAN ONE PIECE shall be limited to $^5/_8$ in. THE LIMITATION OF PLATE THICKNESS DOES NOT APPLY TO HEADS FORMED OF A SINGLE PLATE.

PAR. U-78*a*. Revise to read:

U-78 *Inspection a.* IN THE CASE OF VESSELS BUILT IN ACCORDANCE WITH PAR. U-68 THE MANUFACTURER SHALL SUBMIT THE VESSEL FOR INSPECTION AT SUCH STAGES AS MAY BE DESIGNATED BY THE INSPECTOR. [The inspector may designate stages of the work at which he wishes to inspect the welded joints of a vessel built in accordance with Par. U-68, and the manufacturer shall either submit the vessel for inspection in such partly completed condition, or as an alternative he may permit the inspector to witness stages of the welding operation at such times as the inspector may select.]

PAR. UA-22. Add the following:

e Ring flanges and hubbed flanges may be lap-welded to the end of a vessel or pipe under Pars. U-69 and U-70, as shown in Fig. UA-7*A* and *B*, respectively, provided that:

(1) the flange thickness *t* is at least that required for a loose-ring or loose-hubbed flange, as the case may be, of the same diameter and bolting (see Par. UA-21*a*), without considering the shell or nozzle neck to have any value as a hub;

(2) none of the following limits are exceeded: working pressure of 300 lb per sq in., working temperature of 700 F, required thickness of shell or nozzle neck of $^5/_8$ in., and ratio of inside diameter to thickness of shell or nozzle neck of 300;

(3) the welds attaching the flange to the shell or nozzle neck have dimensions not less than those shown in Fig. UA-7*A* and *B*, where *T* is the actual thickness of the shell or nozzle neck; and

(4) the flange is slipped over the shell or nozzle neck for its full thickness minus the amount required for the weld at the flange face.

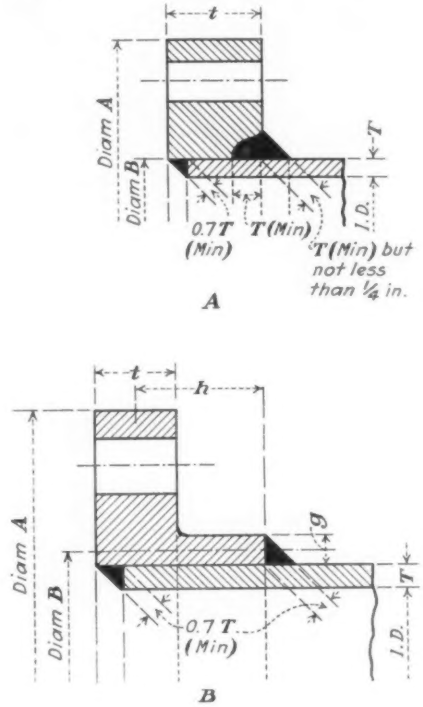


FIG. UA-7

Rules for Containers for Gases and Liquids at Sub-Zero Temperatures Down to 150 F

These rules cover containers for non-corrosive gases and liquids which have no deleterious effect on the steel of the vessel, which containers may be used for the liquefaction or gasification of solid carbon-dioxide. They do not apply to temperatures below minus 150 F, or to vessels designed for atmospheric or higher temperatures, nor do they apply to vessels in which thermal stresses imposed by the conditions of operation will be an important factor.

U-140 *Seamless Containers. a* These containers shall not be used under conditions where there is danger of having holes drilled in the shell. The materials entering into the

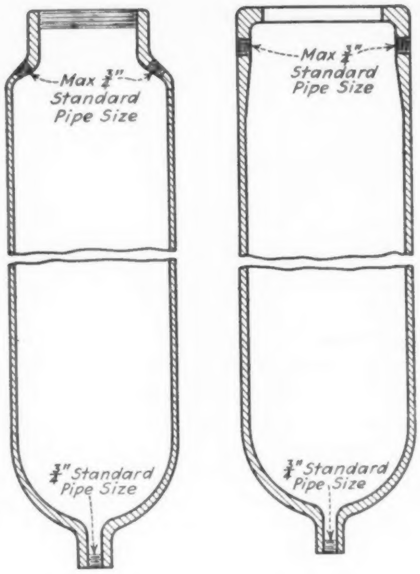


FIG. U-29 TYPICAL SECTIONS OF CONTAINERS FOR LIQUEFACTION OF SOLID CARBON DIOXIDE

manufacture of same shall conform to Specifications S-18 with the following additional requirements:

Only open-hearth or electric-furnace steel of the following grades shall be used:

	Min tensile, lb per per sq in.	Elongation in 2 in., per cent
B..........	62,000	25
C..........	75,000	$22^1/_2$
D..........	90,000	18

b In addition to complying with test specimens in (*a*) cut from one container after heat treatment, from each one hundred containers, or each heat, or each heat treating batch, whichever is the smaller, shall meet Charpy impact tests as described in Par. U-142.

c Design. The containers shall consist of a seamless vessel in which there are no holes in the shell portions. The end or head to which any attachments are made shall be thicker than the shell portion. Two acceptable forms for solid carbon-dioxide containers for use with removable cover plates to provide filling openings and discharge gas openings which shall not exceed $^3/_4$ in. standard pipe size are shown in Fig. U-29. The thickness of the vessel shall be gradually increased near the head in order to avoid stress concentrations and any openings shall be placed in the thickened part at or near the head at a point where the calculated stress before piercing is not more than one-half the maximum allowable stress.

The containers shall otherwise be designed in accordance with all provisions of Section VIII of the Code using the formula in Par. U-20, except that the maximum *S* factor shall not exceed

For Grade B steel......	15,500
For Grade C steel......	18,750
For Grade D steel......	22,500

There shall not be any welding on seamless containers.

U-141 *Welded Containers.* Welded containers shall conform with all of the requirements of Section VIII of the Code and welded in accordance with the requirements of Par. U-68, and in addition, impact tests on base metal and welds shall meet the requirements of Par. U-142. The number of such impact tests shall be the same as the number of tensile tests required for material and welds under Par. U-68, and each impact test shall be the average of three specimens.

U-142 *Impact Properties and Tests. a* Impact properties shall conform to the following tests to be run at the lowest temperature to which containers might be subjected during operating cycle:

b Tests and Test Specimens. Impact tests shall be made on a Standard Charpy or Izod machine, using a standard A.S.S.T. 10 mm × 10 mm specimen with a keyhole notch, where the thickness is $^7/_{16}$ in. or greater. For thinner material a similar specimen shall be used except that the dimension along the axis of the notch shall be reduced from 10 mm to 5 mm. The specimens shall be uniformlv cooled by subjecting them to test temperature for at least 30 min and the handling tongs shall be cooled similarly. The test shall be made within 8 seconds after removal from the cooling medium.

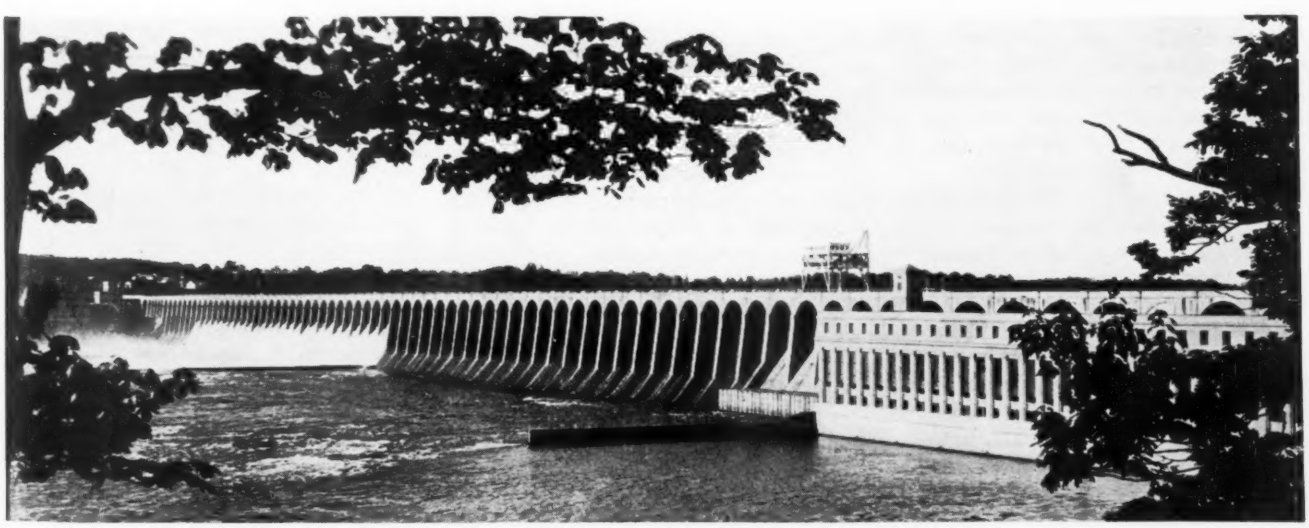
c Number of Impact Tests Required. Impact bars shall be taken in the transverse and longitudinal direction from both seamless and welded containers. In the latter case one set of impact bars shall be taken across the weld with the notch in the weld metal and one set shall be similarly taken but with the notch in the adjacent metal in the heat affected zone. All tests are to be run on bars heat-treated in exactly the same manner as are the containers, and bars shall be heat treated before machining.

U-143 *Safety Devices.* The safety relief device or devices shall comply with the requirements of Par. U-2, and Pars. U-3 to U-10 shall not apply.

U-144 *Stamping.* The stamping required by Par. U-66 shall be applied at some thickened or reinforced portion of the vessel.

TABLE 1

Impact Specimens	—Min Impact Value—Keyhole Notch Specimen— 0 to —75 F Charpy	Izod	—76 to —150 F Charpy	Izod
10 mm × 10 mm.......	15	18	10	10
10 mm × 5 mm........	10	10	4	3
10 mm × 2.5 mm.......	5	4	2	1



WILSON DAM, ON THE TENNESSEE RIVER, IS ONE OF THE PLACES OF INTEREST WHICH MAY BE VISITED EN ROUTE TO THE A.S.M.E. DALLAS MEETING, JUNE 15–20, SEE PAGES 332–336.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Diesel Engineering

Elements of Diesel Engineering, With Questions and Answers. By Orville Adams. The Norman W. Henley Publishing Co., New York, 1936. Cloth, 6 × 9 in., 478 pp., 284 figs., $4.

Reviewed by H. Schreck[1]

NO BETTER statement could be made for this book than to say that the title is far too modest for the ground it covers. It presents earlier as well as recent design details and experience in the operation of Diesel engines on such an extended basis that in the reviewer's opinion, there is no other survey of design details and operating difficulties on the market equal to this book.

As the author states in the preface, the book is a presentation of a wide literature on this subject, but it takes a man of mature experience to bring out only such material as is worth-while and technically correct. Some illustrations are rather old; on the other hand the most recent design details are incorporated in the book.

The chapter on fuel oil is fundamental and good. Its paragraph, "Three Stages in Combustion," could be made more precise, since it has a great bearing on such factors as combustion space and choice of fuel oil. More recent research has changed the former idea that all of the fuel oil injected has to vaporize before it can burn. The author expresses this point indirectly by speaking of instantaneous ignition of the remainder of the fuel. However, this does not explain clearly enough the "three stages" of which the author is speaking.

The chapter on lubricating oil might be built up somewhat more fully in the next edition on such points as qualification of the various oils; and other general descriptions in this chapter could be reduced. The differentiation between asphaltic and paraffin-base oils is good and seldom found in this type of book.

The chapter on pistons and rings gives excellent information.

More space might have been devoted to the Pawlikowski coal-dust Diesel engine which has been for some time under active development in Germany and Great Britain. The dust engine has only been mentioned in connection with the early attempts by Dr. Diesel, who failed with it.

Chapter 5 deals with the spark-ignition engine. The author might revise this chapter after some further study in the operation of these engines. The compression ratio is stated as 7.5 to 1 and a fuel-consumption curve is given on the same basis. It is true that an engine has been run in Sweden by Hesselman under those conditions. However, the selection of fuels which can be used with high compression is extremely limited on account of detonation. The engines built in this country have, therefore, compression ratios of 5 to 6 to 1 with a corresponding fuel consumption of 0.54 to 0.58 lb per bhp-hr (catalog figures) on small high-speed engines against 0.45 and 0.43 lb given in the book. Also the increase of fuel consumption at partial load is much greater than in the Diesel engine It is important to use a fuel oil of minimum ignition delay. The author should bring out these points and explain why spark ignition makes combustion difficult to handle on this engine and why the difficulties increase with the larger size of engine. With extended research they may be overcome. The only advantage claimed for this engine is its lighter weight, but a survey of commercial high-speed engines will show that there is only one automotive Diesel engine which is heavier in weight than the spark-ignition engine. Also this might be improved upon in time.

The author has been rather unfavorable in his judgment on supercharging of Diesel engines, even though he has given both advantages and disadvantages of this system. Actual plants have proved that supercharging in combination with exhaust-gas-driven blowers is of great advantage, particularly when larger units are concerned. The same will apply to airplane Diesel engines of the future.

Fig. 51 shows the Hildebrand combustion chamber in the form of a separate turbulence chamber. This arrangement with two opposed fuel-injection spray valves also has been applied to an open combustion space (see "High-Speed Diesel Engines," by P. M. Heldt, page 190). This last layout by Hildebrand is of particular interest because it is the system adopted on the latest Ingersoll-Rand locomotive Diesel engine.

This book cannot be recommended too highly to mechanics and operating engineers, as well as designing engineers who wish to learn what otherwise can only be acquired over a period of many years in close association with the actual operation of Diesel engines. The theoretical material is held along general lines but is not less valuable to anybody interested in oil engines.

[1] Fairbanks, Morse and Co., Beloit, Wis. Mem. A.S.M.E.

Statistical Methods

The Application of Statistical Methods to Industrial Standardisation and Quality Control. By E. S. Pearson. British Standards Institution, London, 1935. Paper, $5^1/_2 \times 8^1/_2$ in., 161 pp., supp. plates, 5s 6d.

Reviewed by L. K. Sillcox[2]

THE British Standards Institution invited manufacturers to discuss means of obtaining closer cooperation between those engaged in the theoretical development of statistical methods and those whose functions would be to apply them practically to problems of specification and quality. It is desirable to differentiate between the use of statistical methods in problems concerning specification, standardization, and routine production work, and in those involving special research. Dr. Pearson's book deals with the use of the method in the first case.

Section 1 covers the general scope of the treatise, and indicates the manner in which statistical technique can be employed in the solution of many industrial problems, and may even assist in the detection of some of the causes of difficulty in processes, and enable simple routine checks on efficiency to be applied.

Section 2 covers the general problems by means of specific examples, those taken being the tensile strength of malleable-iron castings, the breaking strength of cloth, and the ash content of samples of coal. In the first instance no less than 20,000 test results were selected from 17 different sources, and then, being carefully tabulated, were plotted as a dot

[2] Vice-President, The New York Air Brake Company, Watertown, N. Y. Mem. A.S.M.E.

diagram, which clearly indicated those specimens that fell outside specification requirements. From the figures it becomes apparent that the mere statement of maximum and minimum strength does not give an adequate measure of variation, for one abnormal sample would most unfairly influence the result, and this indicates the need for establishing standardized deviations.

Section 3 describes what the author terms the "tools" of the statistician; and it is also pointed out how information may be presented, not only by the simple dot diagram, but when the number of observations is extensive, by a frequency distribution; and quick appreciation is brought to bear upon the value of range of variation. When there is no great lack of symmetry the mean and standard deviations provide a useful indication of the limits within which variation may readily be determined. When variation is uniform the greater the number of observations, the nearer the frequency distribution will be to a smooth curve.

Section 4 comprises the important subject of sampling and the statistical theory relating thereto, the relation of the sample to the batch is investigated, while an examination of the logical inferences that may be drawn reveals the value of this new method. For instance, if it is known from past experience, carefully analyzed, that the distribution curve of length of life for a given type of electric lamp follows the normal law, and has a mean of 100 hours and a standard deviation of 300 hours, the statistician can predict that the chance of the mean length of life in a random sample of 20 lamps falling below 800 hours is 0.0014. The method of sampling is important, and useful observations are contained on the subject.

In Section 5 the statistical theory is developed in connection with specifications, and the basis of securing conformity to specifications. Statistical theory is of assistance in providing assurance for the user on the adequacy of the sampling, and also information for the producer that no unexpected variations in his processes are affecting the quality of his goods. It is essential to obtain a sample that is truly typical of a consignment, but it is not always easy. A simple case is that of a sheet of steel, where, owing to irregularities of rolling, samples taken from the edge of the plate may be quite different from those near the center. Regular statistical methods of sampling must necessarily reveal this. From the user's standpoint it is highly desirable that he should know that the producer's level of control remains constant, and for this reason, if statistical control is resorted to by the producer, he should see to it that the records are made available to the user. There must always exist a certain element of risk in cases where consignment sampling obtains, but one who studies and measures this variability is in a much more stable state in determining at what level control should be established. The expense of haphazard sampling to give adequate assurance may prove costly, whereas sampling on a statistical basis should effect considerable economies.

Section 6 shows the statistical relationship between sample and batch, and discusses the variation of mean and standard deviation in samples. This is illustrated again by the case of the electric lamps in which, if a whole batch of several thousands were tested, it would be possible to determine the mean efficiency and the standard deviation of efficiency. In practice, of course, this would be quite impracticable, and trials could only be made on several samples, each containing, for instance, ten lamps. The values now would be found to vary individually from those calculated for the entire batch. The extent of these differences is of importance in assessing reasonable limits for specified requirements. Simple mathematical formulas are deduced, and in a table the results secured from them are compared with those from a much more elaborate system of observations, and the agreement, if not perfect, is good enough for practical purposes.

Section 7 is full of interest to engineers, because in it is explored the use of statistical methods in securing conformity with specification by consignment sampling, especially bearing in mind the fact that the conditions laid down must frequently relate to a number of characteristics, sometimes independent, sometimes interrelated. The method presented is clearly described as showing a system of classification on a statistical basis, and illustrates the case by taking four makes of sand-lime bricks, divided into two grades on the basis of strength and uniformity. They are graded by means of standard deviation and also by mean and coefficient of variation. It cannot be argued that it is important to have a preliminary investigation before the requirements for sampling and testing in a specification are fixed. Aside from the purely statistical points, other practical and economic considerations naturally have to be carefully discussed. It is not claimed that statistical methods yield everything, but they surely set forth the facts in such a fashion that the characteristics can be observed, and full advantage taken of them.

Section 8 goes a step further and demonstrates by means of control charts how statistical analysis may prove a useful tool in locating sources of trouble. The essence of the method lies in gathering together, and arranging suitably, test records, so that lack of uniformity may at once be detected. It will then be possible to decide whether the cause of variation may be termed "assignable" or "chance." If the former, the first indication has been given that a thorough investigation is warranted. In all this work the normal method of approach of any scientific inquiry has been taken, that of making a hypothesis and then carrying out trials to assign whether or not observed facts conform to it.

In a number of these control charts the standard deviation of the batch is really the basis, and if a diagram is drawn showing the standard deviation above and below the mean, the belt across the diagram between these two lines will indicate the area of control. The narrower the belt the more exacting would be the specification. The determination of the standard deviation must naturally depend largely on past experience. It should be mentioned that these charts are valuable, not only in checking conformity to standard, but also in the hands of a careful investigator can be made to reveal much that is suggestive from a study of the dot pattern. Two figures are shown, each in connection with an examination of the ash content of coal, in one case the mean being 7.49 and standard deviation 2.25, while in the second case they are 8.39 and 4.62, respectively. From an inspection of the control charts it is at once apparent that the ash content in the second case was the greater, and by further analysis the fact is revealed that characteristic features of lack of control are evident in the second case, but not in the first. In a similar manner, the quality of electric lamps is considered, and in this case not only is the average life at a definite efficiency important, but also the variability in life above the average value. Another example shows how a chart may be employed in connection with the improvement of a technical process involved in the production of a manufactured chemical, and also suggests the form of statistical check on the maintenance of the level of control. When the chart shows that variations are due to assignable causes, these are carefully investigated by those in charge, who alter the processes with a view to improvement. At a later stage a second control chart is prepared, and if the ex-

pert action previously taken has been a sound one, the results are clearly shown on the new chart. After carefully reading this section it is clear that a wide field of exploration lies open to the enterprising process manufacturer.

Section 9 is concerned with performance tests and indexes of quality. There are cases in which no qualitative or quantitative measures of comparison obtain, but where the user is anxious to assure himself that the material he is securing is the same as his last consignment, and it is this sameness that the statistician must resolve into some form that will meet both user and producer needs. This is a more difficult problem than those already discussed and it is only touched upon lightly.

In reorganizing a manufacturing industry, usually one of the first steps is to introduce an efficient system of cost accounting, and if this is one that aims at a high degree of accuracy, such as the machine-hour-rate method, a mass of statistical information is essential.

Marketing

THE PRINCIPLES OF MARKETING, by Henry F. Holtzclaw. Thomas Y. Crowell Co., New York, N. Y., 1935. Cloth, 6 × 8 1/2 in., 694 pp., $3.75.

REVIEWED BY GEORGE W. KELSEY[3]

IN VIEW of the author's expressed intention of providing a comprehensive introduction to the marketing of agricultural and manufactured consumer products, for the use of students in colleges and schools of business administration as well as business men and others interested in the distribution of goods, Dr. Holtzclaw, professor of commerce at the University of Kansas, has left little to be desired in his latest work.

Those who look to this volume for helpful material on technique in any one of the many operations covered are forewarned of their disappointment. The author confines himself to what is being done and why, rather than how.

The book may be characterized as an orderly compendium of the subject, amplified and clarified by interesting examples. It is replete with references. Several questions and problems are given at the end of each chapter.

This work naturally invites comparison with earlier books by writers such as Paul Cherington, Edmund Brown, Jr., Frederick E. Clark, Ralph Breyer, and others. It differs essentially from its predecessors in the matter of timeliness. Many significant changes have occurred in the realm of distribution during the past few years and it appears that few, if any, of the more important of these have been overlooked by the author.

[3] Chairman, A.S.M.E. Management Division Executive Committee; President, G. W. Kelsey and Company, Research Engineers, New York, N. Y. Mem. A.S.M.E.

Books Received in Library

ADSORPTIONSTECHNIK. (Technische Fortschrittsberichte, Bd. 34.) By F. Krczil. Edited by B. Rassow. Theodor Steinkopff, Dresden and Leipzig, 1935. Paper, 6 × 9 in., 132 pp., illus., diagrams, charts, tables, 8.50 rm. This monograph affords a comprehensive review of the industrial uses of adsorption. The preparation and investigation of the various adsorbents, and their uses in the purification and separation of gases, vapors, and liquids are discussed in detail. A list of German, English, French, and Austrian patents is included.

AIRPLANE INSTRUMENTS; THEORY OF FLIGHT. By J. R. Allen. HISTORY OF AVIATION; AIRPLANE DETAILS. By F. W. Wead and J. R. Allen. PRACTICAL FLYING AND METEOROLOGY. By F. W. Wead and J. R. Allen. International Textbook Co., Scranton, Pa., 1935. Leather, 5 × 8 in., illus., diagrams, charts, tables, maps, respectively, $2.70, $1.75, and $2.35. These three volumes form a course of practical instruction in aviation, covering the rudiments of training for pilots and ground men. The treatment is nonmathematical and easily understandable.

AMERICAN SOCIETY FOR TESTING MATERIALS. Proceedings of the 38th Annual Meeting held at Detroit, Mich., June 24–28, 1935, vol. 35, parts 1 and 2. American Society for Testing Materials, Philadelphia, 1935. Vol. 1, 1488 pp.; vol. 2, 769 pp. Leather, cloth, and paper, 6 × 9 in., illus., diagrams, charts, tables. Leather, $15, cloth, $12, paper, $11. The Proceedings for 1935 appear in two substantial volumes. Volume 1 contains the reports of the standing committees of the Association, the Tentative Standards that were issued or revised during 1935, and the tentative revisions of Standards now under discussion. Volume 2 contains the technical papers presented before the Association.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS GUIDE 1936 for Heating, Ventilating, Air Conditioning. American Society of Heating and Ventilating Engineers, New York, 1936. Leather, 6 × 9 in., 1080 pp., illus., diagrams, charts, tables, $5. This book comprises in one volume the technical data needed by engineers engaged in the design and operation of heating, ventilating, and air-conditioning systems; a representative collection of manufacturers' data on equipment; and a directory of the members of the American Society of Heating and Ventilating Engineers. The new edition has been thoroughly revised and amplified. Chapters have been added on refrigeration, drying, motors and their control, railway air conditioning, and heat and fuel utilization. The volume is an exceedingly useful reference work.

ANNUAL TABLES OF CONSTANTS AND NUMERICAL DATA: Chemical, Physical, Biological, and Technological. Vol. 10, 1930, Part 2. McGraw-Hill Book Co., New York, N. Y., 1935. Cloth, 9 × 11 in., 609 pp., diagrams, charts, tables, $20 for both parts, not sold separately. This series of volumes is an indispensable one for any research library or scientific laboratory, for it provides directly all the new numerical data in every field of science, and thus obviates the necessity of long searches. Among the matters of special interest to engineers are data upon the mechanical properties of building materials; the thermal properties of fuels and refractories; and the equilibrium diagrams and thermal, electrical and mechanical constants of metals and alloys. Full literature references are given.

ATOMIC PHYSICS. By M. Born, authorized translation from the German edition by J. Dougall. G. E. Stechert & Co., New York, 1936. Cloth, 6 × 9 in., 352 pp., illus., diagrams, charts, tables, $4.75. A comprehensive review of modern atomic physics is provided in brief compass by this book, which is based upon a series of lectures given at the instance of the Verein deutscher Electrotechniker and published in German in 1933. The translation has been thoroughly brought up to date, a new chapter having been added upon the discovery of new particles and the properties of nuclei.

DAVISON'S TEXTILE CATALOGUES and Buyers Guide, 1935. Davison Publishing Co., New York. Cloth, 9 × 12 in., 348 pp., illus., $12. This volume provides a handy collection of condensed catalogues for the purchasing agents of textile supplies. The collection covers machinery, equipments, supplies, and services used by manufacturers, dyers, and finishers of textiles, and is extensively indexed for quick reference.

DIESEL ENGINES, Operation and Maintenance. By L. H. Morrison. American Technical Society, Chicago, 1936. Cloth, 6 × 9 in., 212 pp., illus., diagrams, charts, tables, $2.25. This is a practical textbook on the subject, intended for students and beginners. The text is clear and concise and adapted for home study. The troubles that are likely to occur in operating heavy-duty engines are described and methods of adjustment and repair explained.

EINFÜHRUNG IN DIE TECHNISCHE STRÖMUNGSLEHRE, Vol. 2. Strömungstechnisches Praktikum. By B. Eck. Julius Springer, Berlin, 1936. Leather, 6 × 9 in., 96 pp., illus., diagrams, charts, tables, 6.90 rm. Having presented the fundamentals of aerodynamics in his first volume, Dr. Eck devotes the present one to the technique of experimentation. It contains directions for the experimental proof of the theoretical principles enunciated in the first volume, using comparatively simple apparatus.

ELEMENTARY ENGINEERING THERMODYNAMICS. By V. W. Young and G. A. Young. McGraw-Hill Book Co., New York and London, 1936. Cloth, 6 × 9 in., 220 pp., diagrams, charts, tables, $2.50. This text presents a course, about three semester hours in length, which will provide the fundamental theoretical basis for an accompanying course in practical heat engineering. The treatment is brief, yet fairly comprehensive, and avoids the more complicated mathematical processes.

ELEMENTS OF DIESEL ENGINEERING with Questions and Answers. By O. Adams. Norman W. Henley Publishing Co., New York,

1936. Cloth, 6 × 9 in., 478 pp., illus., diagrams, charts, tables, $4. The principles, construction, and operation of these engines are discussed without the use of mathematics in this manual, which is intended especially for the would-be practical engineer. The information is clear and practical, and review questions are added for the benefit of home students. (Reviewed in this issue.)

FORD PRODUCTION METHODS. (*Mill and Factory*, January, 1936.) Conover-Mast Corporation, New York. Leather, 9 × 12 in., 590 pp., illus., diagrams, charts, maps, tables, $1. The January, 1936, number of *Mill and Factory* is devoted to a single topic, Ford production methods. Based on an extended study by the editor, Hartley W. Barclay, the report is a comprehensive survey of the equipment and methods of the Ford plant. The benefits of continuous modernization are emphasized. The issue is bound in a substantial cover.

FORSCHUNGSHEFT 376. INDIZIEREN SCHNELLAUFENDER VERBRENNUNGSKRAFTMASCHINEN. By E. Kallhardt; SCHWINGUNGEN VON LUFTSÄULEN, MIT GROSSER AMPLITUDE, by C. Mayer-Schuchard. V.D.I. Verlag, Berlin, January–February, 1936. Paper, 8 × 12 in., 22 pp., illus., diagrams, charts, tables, 5 rm. The first of the reports in this issue gives the results of comparative tests of the suitability of various indicators for high-speed internal-combustion engines. Optical, stroboscopic, and piezo-electric indicators were tested comparatively, the last proving most accurate. The second report is concerned with the vibration of gases in pumps, gas-engine intake and exhaust tubes and similar pipes. The phenomena of vibrations of large amplitude were studied experimentally and compared with the results of theoretical investigations.

FORTSCHRITTE DES CHEMISCHEN APPARATEWESENS. ELEKTRISCHE OFEN, Lieferungen 2–3. Edited by A. Bräuer, J. Reitstötter, and H. Alterthum. Akademische Verlagsgesellschaft, Leipzig, 1935. Paper, 8 × 11 in., diagrams, tables, 28 mk. each. This treatise on the electric furnace provides a detailed review of its development, construction, and uses based upon the German patents. The work is exceedingly comprehensive. Each development is covered concisely in the text, with references to the corresponding patent. Abstracts of all German patents in the field are given, as well as a classified numerical list of British patents. The work is a valuable addition to the literature of the subject.

GRAPHS, How to Make and Use Them. By H. Arkin and R. R. Colton. Harper & Bros., New York and London, 1936. Cloth, 6 × 10 in., 224 pp., illus., diagrams, charts, tables, $3. The beginner will find this an excellent introduction to the subject. The directions are clear and simple, and cover all the usual methods of graphic representation. A wide variety of uses in business, economics, engineering, and other fields are illustrated.

Great Britain, Air Ministry, Aeronautical Research Committee, Reports and Memoranda No. 1638, MEASUREMENT OF WATER PRESSURE ON THE HULL OF A BOAT SEAPLANE, by E. T. Jones and W. H. Davies. His Majesty's Stationery Office, London, 1935. Paper, 6 × 10 in., 46 pp., illus., diagrams, charts, tables, 3s 6d. This publication reports the results of recent measurements of a Southampton boat seaplane, recorded at twenty-three stations during a series of normal landings and take-offs at different weights and during abnormal landings at one weight.

Great Britain, Department of Scientific and Industrial Research. Report of the FOOD INVESTIGATION BOARD for 1934. His Majesty's Stationery Office, London, 1935. Paper, 6 × 10 in., 261 pp., illus., diagrams, charts, tables, 4s or $1.25, obtainable at British Library of Information, N. Y. The report describes the investigations carried on during the year. Various problems connected with the storage, shipment, and preservation of meat, fish, fruit, and vegetables were studied, including certain matters of engineering.

HANDBOOK OF APPLIED MATHEMATICS. By M. E. Jansson and H. D. Harper, with a section on Business Mathematics, by P. L. Agnew. Second edition. D. Van Nostrand Co., New York, 1936. Leather, 5 × 8 in., 1010 pp., illus., diagrams, charts, tables, $6. The first section of this book reviews briefly the operations of arithmetic, algebra, geometry, and trigonometry. The remaining chapters show the applications of mathematics in various trades; carpentry, plumbing, machine-shop work, printing, business, etc. Worked problems are used throughout to illustrate the uses. Many tables of data are included. The book affords a good course in practical mathematics for workmen. The new edition has been revised and enlarged.

INDUSTRIELLE ELEKTROWÄRME, herausgegeben von der Wirtschaftsgruppe Elektrizitätsversorgung by Masukowitz and Knoops. Arbeitsgemeinschaft zur Förderung der Elektrowirtschaft, Berlin, 1935. Paper, 6 × 8 in., 64 pp., illus., diagrams, charts, tables, 1 rm. This publication describes briefly, in popular style and largely by photographs and drawings, the development of the electric furnace and its advantages. The economy of electric heating, the types of furnaces available, and their various applications are described. The book is issued by the electrical industries.

XIV. KONGRESS FÜR HEIZUNG UND LÜFTUNG, June 26–28, 1935, in Berlin. BERICHT herausgegeben vom Ständigen Kongressausschuss. R. Oldenbourg, Munich and Berlin, 1935. Paper, 7 × 10 in., 175 pp., illus., diagrams, charts, maps, tables, 8 rm. The report of the congress contains nineteen papers upon heating and ventilation. This describes advances in technique since the previous congress in 1930, emphasizing changed viewpoints concerning the relations of heating to the national fuel problem, the social advantages of good ventilation, and other broad questions.

MATHEMATICS OF MODERN ENGINEERING. Vol. 1. By R. E. Doherty and E. G. Keller. John Wiley & Sons, Inc., New York, 1936. Cloth, 6 × 9 in., 314 pp., charts, tables, $3.50. This book, originally developed for the advanced course in engineering of the General Electric Company, is intended to facilitate the study and use of mathematics with especial reference to its applications in engineering. The text covers those branches of the subject which have been found most useful in engineering, including ordinary differential equations, determinants, Fourier series, transcendental equations, dimensional analysis, vector analysis, and Heaviside's operational calculus. The scientific approach to the problems is emphasized. A knowledge of the calculus is necessary for use of the book.

LE MOTEUR À EXPLOSIONS, Vol. 2. By R. Devillers and P. Mercès. Third edition. Dunod, Paris, 1935. Cloth and paper, 8 × 11 in., 1486 pp., illus., diagrams, charts, tables; bound, 410 fr.; paper, 385 fr. This volume concludes the new edition of this valuable treatise on the gas engine, the first part of which appeared some months ago. The work treats comprehensively of theory and design, and affords a clear account of modern views and practice, which will have great interest to automobile and airplane engineers.

NATIONAL ASSOCIATION OF RAILROAD AND UTILITIES COMMISSIONERS. Proceedings of 47th Annual Convention held at Nashville, Tenn., October 15–18, 1935, published by the State Law Reporting Company, official reporter for the National Association of Railroad and Utilities Commissioners, New York City, 1936. Cloth, 6 × 9 in., 591 pp., tables, $6. The topics to which the 1935 convention of the Association was devoted were: The consequences of the Public-Utility Holding Company act of 1935; the regulation of motor-vehicle carriers using public highways; the effect of recent judicial decisions on state regulation; Federal and state jurisdiction over telephone companies as affected by the Federal Communications act; and state regulation and its results. The Proceedings contain the addresses and discussions on these subjects, and the reports of the various committees of the Association.

(THE) NEXT HUNDRED YEARS, the Unfinished Business of Science. By C. C. Furnas. Williams & Wilkins, Baltimore, 1936. Cloth, 6 × 9 in., 434 pp., $3. This is an interesting description of the present state of scientific knowledge of biology, chemistry, and physics and of the social consequences of their development, intended for the general reader. The attitude of the author is a critical one, and he emphasizes what science hopes to do, rather than what has been done. The book is lively and stimulating.

PETROLEUM REFINERY ENGINEERING. By W. L. Nelson. McGraw-Hill Book Co., New York and London, 1936. Cloth, 6 × 9 in., 647 pp., illus., diagrams, charts, tables, $6. This book, which is mainly concerned with the fundamentals of engineering design and processing, is a valuable addition to the literature of refining and a useful supplement to other books on that subject. The practical phases of engineering work are emphasized, and the book is intended to aid in clarifying the questions of detail that arise during plant operation and to encourage fuller use of the principles of chemical engineering. Useful select bibliographies accompany the various chapters.

PROCEDURE HANDBOOK OF ARC WELDING DESIGN AND PRACTICE. Third edition. Lincoln Electric Co., Cleveland, Ohio, 1935. Leather, 6 × 9 in., 596 pp., illus., diagrams, charts, tables, $1.50. This handbook, designed for convenient reference, describes the various forms of the arc-welding process, supplies the essential data for welding various metals, and discusses the designing of structures and machines for arc-welded construction. This new edition has been enlarged by the inclusion of more complete information on welding procedure and new applications of arc welding.

SEAPLANE FLOAT AND HULL DESIGN. By M. Langley. Pitman Publishing Corporation,

London and New York, 1935. Cloth, 6 × 9 in., 131 pp., illus., diagrams, charts, tables, $2.25. In this presentation of the subject, the seaplane is regarded as a ship with wings, rather than as an airplane with a bulky underslung hull. The book is based upon lectures at the De Haviland Aeronautical Technical School, and aims to present the basic principles of design in a digestible form. Only simple arithmetic is required to solve the problems. The work is an excellent, practical introduction to the subject.

SEARCH FOR TRUTH. By E. T. Bell. Williams & Wilkins Co., Baltimore, 1934. Cloth, 6 × 9 in., 293 pp., tables, $3. In the present volume Professor Bell traces the history of the development of logic and the scientific method by man, in his attempt down the ages to solve the riddles of the world he lives in. The story of man's effort to think straight, to discover the truth is told in a lively manner, in a way that requires no special previous knowledge on the part of the reader. A sparkling, stimulating, as well as sound work.

DIE STRÖMUNG UM DIE SCHAUFELN VON TURBOMASCHINEN, Beitrag zur Theorie Axial Durchströmter Turbomaschinen. By F. Weinig. Johann Ambrosius Barth, Leipzig, 1935. Paper, 7 × 10 in., 142 pp., diagrams, charts, 16 rm.; bound, 17.50 rm. This volume presents a thorough study of potential flow through the blade systems of axial-flow turbines. The book is intended for the designer and the application of the theoretical conclusion to the blading of actual turbines is illustrated.

SURFACE CONDENSER, a Survey of Modern Condenser Practice. By B. W. Pendred. Pitman Publishing Corporation, London and New York, 1935. Cloth, 6 × 9 in., 144 pp., illus., diagrams, charts, tables, $2.50. The mathematical side of condenser design has been dealt with in several books, but there has been, the present author believes, some neglect of the problems of practical design. In the present book, which avoids mathematics, he describes in some detail the various types of surface condensers that are manufactured in Great Britain and points out the ways in which the opinions of the various manufacturers differ. The book is based upon a series of articles that appeared in *The Engineer*. It presents much information of interest to designers and manufacturers which is not readily accessible elsewhere.

SYMPOSIUM ON THE WELDING OF IRON AND STEEL. 2 Vols. Iron and Steel Institute, London, 1935. Vol. 1, 676 pp.; vol. 2, 974 pp. Cloth, 6 × 9 in., illus., diagrams, charts, tables, £2 2s. These two large volumes contain the proceedings of a symposium which was organized by the Iron and Steel Institute in conjunction with the other engineering societies of Great Britain and was held in May, 1935. The objects were to review the position of welding in all its industrial aspects, to learn the problems encountered in welding by the various industries, to ascertain what research work is in progress and to stimulate further efforts. The proceedings contain one hundred and fifty papers upon practice and problems in the engineering industries; welding practice, technique and apparatus; the metallurgy of welding; and specification, inspection, and testing. They form a valuable record of recent progress and present welding practice throughout the world, in all important industries.

TECHNICAL DATA ON FUEL, fourth edition. Edited by H. M. Spiers. British National Committee, London, World Power Conference, 1935. Leather, 5 × 8 in., 358 pp., diagrams, charts, tables, 12s 6d (obtainable from American Committee, World Power Conference, Interior Bldg., Washington, D. C.) This useful reference book first appeared in 1928 as a British contribution to the London Sectional Meeting of the World Power Conference. New editions appeared in 1930 and 1932, and a fourth edition, including much new material is now ready. The volume aims to bring together authoritative information that is constantly needed by those interested in the preparation and use of fuels. A wide range is covered, and much hitherto unpublished material has been incorporated. Fuel technologists will find the book very useful.

TECHNIK GESCHICHTE. Im Auftrage des Vereines deutscher Ingenieure. Edited by Conrad Matschoss. (Beiträge zur Geschichte der Technik und Industrie, Bd. 24, 1935.) V.D.I. Verlag, Berlin. Cloth, 9 × 12 in., 148 pp., illus., diagrams, charts, tables, 12 rm. In commemoration of the centenary of German steam railroads, the current volume of this annual is devoted to railroad developments, especially German ones. Papers are included that are devoted to the first German locomotive builders, on railway contributions to structural engineering and to materials, on the history of car wheels and signal apparatus, etc.

DIE TECHNIK IN DEN BERLINER MUSEEN. Berlin, V.D.I. Verlag, 1935. Paper, 4 × 8 in., 24 pp., 0.50 rm. This pamphlet, prepared by the Verein deutscher Ingenieure, is a handy guide to the technological and engineering resources of the Berlin museums. The locations, hours, and principal exhibits of twenty-two institutions in the city of Berlin are described.

TECHNOKRATIE WELTWIRTSCHAFTSKRISE und ihre endgültige Beseitigung. Physikalische Quellenforschung und Zielsetzung der Technokratie. By K. Resar. C. Barth Verlag für Wirtschaft und Architektur, Vienna, 1935. Paper, 6 × 8 in., 203 pp., diagrams. The author of this work presents a plan for a social and economic organization based upon the theories of technocracy.

THÉORIE INVARIANTIVE DU CALCUL DES VARIATIONS. (Institut Belge de Recherches Radioscientifiques, Vol. 4.) By T. de Donder. New edition. Gauthier-Villars & Co., Paris, 1935. Paper, 6 × 10 in., 230 pp., tables, 35 fr. This book presents in systematic fashion the contributions of the author to the theory of the calculus of variations. The first two sections present the Invariantive theory developed by Professor Donder and his pupils. The third section discusses the applications to mathematical physics, in deriving the fundamental formulas of the electromagnetic field, the field of gravity, undulatory mechanics and of radio. A bibliography of Professor Donder's writings is appended.

TRANSIT ENGINEERING, Principles and Practice. By J. K. Tuthill. Planographed and published by John S. Swift Co., St. Louis, Chicago, New York, 1935. Paper, 8 × 11 in., 334 pp., illus., diagrams, charts, tables, $4.50. This textbook presents an up-to-date account of electric-railway practice, covering all phases of the subject. Power generation and distribution, motors, brakes, cars and car equipment, feeder systems, train control, and other matters are discussed. Chapters are given to electric locomotives, gasoline, oil-electric and other self-propelled cars and trains, and to motor and trolley omnibuses. A considerable quantity of useful information on the history of electric railways is summarized conveniently.

TRAVAUX MARITIMES, Vol. 3. (Bibliothèque de l'Ingenieur de Travaux Publics.) By L. Prudon. Dunod, Paris, 1936. Cloth and paper, 5 × 7 in., 432 pp., illus., diagrams, charts, tables; cloth, 87 fr; paper, 78 fr. The third volume of this treatise treats of the construction and maintenance of the works used in circulation and in loading and repairing ships. Landing quays, locks and passages, tide basins, lock gates, drydocks, and caissons are described, with numerous examples of important works.

V.D.I.—JAHRBUCH, 1936, Die Chronik der Technik. V.D.I. Verlag, Berlin, 1936. Paper 6 × 8 in., 192 pp., tables, 3.50 rm. The Jahrbuch provides a convenient review of the principal developments in engineering during the year 1935, in the form of eighty-three summaries by specialists. Full references to the original articles accompany each essay. All branches of technology are covered, and about 6000 articles are cited. The German-reading engineer will find the book a useful reference work.

TURNING AND BORING PRACTICE, Modern Machines, Tools, and Methods Used in Representative Plants. By F. H. Colvin and F. A. Stanley. McGraw-Hill Book Co., New York and London, 1936. Cloth, 6 × 9 in., 453 pp., illus., diagrams, charts, tables, $4. This book describes engine lathes, turret and semiautomatic lathes, automatic screw machines and boring machines, and illustrates the ways in which they are used by numerous examples. Advice is also given on the selection of cutting tools for different materials, on speeds, and on cutting oils. The volume offers much practical information on modern machine-shop methods.

V.D.I. (Verein deutscher Ingenieure), Sonderheft LUFTFAHRT. V.D.I. Verlag, Berlin, 1936. Paper, 6 × 12 in., 132 pp., illus., diagrams, charts, tables, 6 rm. This special number of the *V.D.I. Zeitschrift* contains a collection of the more important papers on aeronautics which have appeared in recent issues of that periodical or in the *Forschung auf dem Gebiete des Ingenieurwesens*. In general, attention is given to developments in research work, transport and military airplanes, and airplane engines. The brochure brings the results of recent work together in convenient form.

WASSERGAS, Chemie und Technik der Wassergasverfahren. By P. Dolch. Johann Ambrosius Barth, Leipzig, 1936. Cloth and paper, 7 × 10 in., 268 pp., diagrams, charts, tables; paper, 15.60 rm.; bound, 17 rm. The first section of this treatise is devoted to the chemistry of the basic chemical reaction involved in making water gas, the action of steam upon incandescent fuel. The evolution of our knowledge of this subject is traced chronologically. The remainder of the book discusses the practical manufacture of water gas, describing the various processes that are ordinarily used. The volume is an excellent blend of theoretical and practical information.

WHAT'S GOING ON

Including News of A.S.M.E. Affairs

This Month's Authors

CARL F. GREENE, author of the article entitled "Stressed-Skin Construction," holds the rank of captain in the Air Corps of the United States Army and is stationed at Wright Field. Captain Greene was born in Canada and educated in Canadian schools, later attending Purdue and then Columbia University. He joined the Army in 1917 and during the War was transferred to the Air Service. He has been instrumental in developing and applying "stressed skin" in monocoque construction to airplanes which resulted in the general transition from the 100 mph biplane with its stick and wire net work to the present smooth metal monoplane capable of better than 200 mph. It is his belief, and he has tried to stress this in his paper, that modern aircraft structural engineering has stimulated and inspired the present marked demand for true engineering economy, simplicity, and grace in many forms of construction other than aircraft.

H. T. Sawyer, Jun. A.S.M.E., author of the article on "An Indicator for High-Speed Engines," is mechanical engineer with the Bailey Meter Company, Cleveland, Ohio, and is engaged in sales-service work. From 1929 to 1931 he was a student at the General Electric Student Engineering School and Test Course. He was graduated from Rensselaer Polytechnic Institute in 1935 with the degree of M.E., and that year was awarded first prize at the New England Student Branch Conference of the A.S.M.E. for his thesis on "An Indicator for High-Speed Engines," on which his present paper is based.

E. T. Vincent, Mem. A.S.M.E., who is chief engineer of the Diesel Engine Division of the Continental Motors Corporation is the author of the paper entitled "Design of Light-Weight Compression-Ignition Engines." Mr. Vincent took the naval-engineering course in His Majesty's Dockyard, Chatham, followed by a special engineering course at the Imperial College of Science and Technology, South Kensington, London, England. He received the degree of Bachelor of Science with Honors from London University and in 1914 the Royal Scholarship, Whitworth Exhibition. In 1916 under the Whitworth Scholarship he conducted research work on high-speed and light-weight compression-ignition engines at the Admiralty Engineering Laboratories. In 1916 he became a designer in His Majesty's Dockyard, Chatham, England, and then senior laboratory assistant in charge of engine tests and allied experimental work on submarine Diesel engines of advanced designs. In 1919 Mr. Vincent was appointed technical secretary to the superintendent of the Admiralty Engineering Laboratories in Great Britain. Three years later he became chief experimental engineer of W. Beardmore & Co., Glasgow, Scotland, where he was responsible for the development of the Diesel engines of the British dirigible R 101 together with their light-weight rail-car oil engine. From 1926 to 1930 he served as engineer on aircraft Diesel-engine experimental work with the Aero Engine Company, Los Angeles, Cal. Since 1930 he has been with the Continental Motors Corporation.

G. W. Plinke, who writes on "Gas Welding of Class-1 Pressure Vessels," is director of research of the Henry Vogt Machine Company in Louisville, Ky. Mr. Plinke is a graduate of Purdue University and holds the degree of B.S. in mechanical engineering. He joined his present concern in 1924 and in 1930 was given charge of development work and welding. In this capacity he has devoted a major portion of his time to the study of welding carbon and alloy steels. He has also done considerable work on the X-ray testing of welds and is the author of a number of publications in this field.

R. H. Heilman who writes on "Emissivities of Refractory Materials" is senior industrial fellow at Mellon Institute, Pittsburgh. For the past nineteen years Mr. Heilman has been making studies of the transfer of heat from bare and insulated surfaces and many of his papers are to be found in the Transactions of the A.S.M.E. He has been interested in the development of insulating materials for low- and high-pressure steam and for industrial furnaces.

Howard W. Haggard, author of "Work and Fatigue," is associate professor of applied physiology at Yale University. He received the degrees of Ph.B. in 1914 and M.D. in 1917 from Yale University. During the War he served as captain in the chemical-warfare service. He was formerly consulting physiologist with the U. S. Bureau of Mines. His main researches have been on noxious gases. He has written many scientific papers on physiological subjects.

Elizabeth Faulkner Baker, author of the article on "Human Problems Created by Labor-Saving Machinery" is assistant professor in economics at Barnard College, Columbia University. Professor Baker received the degree of B.L. from the University of California in 1914, A.M. and Ph.D. from Columbia in 1919 and 1925, respectively. From 1915 to 1917 she was instructor in economics and dean of women at the State Normal School in Lewiston, Idaho. The following year she was dean of women at the State Normal School, Ellensburg, Wash. In 1919 she joined the faculty of Barnard College as an instructor in economics and in 1926 was appointed assistant professor. Professor Baker was the American member of the committee on careers for women of the International Federa tion of Women, 1924–1928. She is a member of the American Economic Association, the American Association for Labor Legislation, American Association for Social Security, and the Taylor Society.

Corris S. Viteles is an assistant professor of psychology at the University of Pennsylvania. He has been actively engaged in the field of industrial psychology for the past fifteen years. He has functioned as consulting psychologist for the Philadelphia Electric Co., the Detroit Edison Co., the Milwaukee Electric Railway & Light Co.

Lillian M. Gilbreth, Mem. A.S.M.E., is president of Gilbreth, Inc., consulting engineers in management. Dr. Gilbreth received the degrees of B.Litt. and M.Litt. from the University of California in 1900 and 1902, respectively; Ph.D. and Sc.D. from Brown University in 1915 and 1931; Mech. Engg. from University of Michigan in 1928; Dr. Engg. from Rutgers in 1929; Sc.D. from Russell Sage College in 1931; and LL.D. from the University of California in 1933. Dr. Gilbreth directs courses in motion study and "the one best way to do work." She has served as a member of the President's Emergency Committee for Unemployment; of the President's Organization on Unemployment Relief; of the New Jersey State Board of Regents, 1929–33; of the American Management Association; Institute of Management; Taylor Society; Acad. Masaryk; American Psychological Association; A.S.M.E.; and Institute for Scientific Management of Poland. She is an honorary member of the Society of Industrial Engineers.

Olin Ingraham, who reviews Arthur D. Gayer's book on "Public Works in Prosperity and Depression" in his article in this issue, is a member of the department of economics and social science of the Massachusetts Institute of Technology.

Repairs by Fusion Welding on Boilers and Pressure Vessels

THE National Board of Boiler Pressure Vessel Inspectors in cooperation with the Engineers' Conference of the Boiler and Machinery department of the National Bureau of Casualty and Surety Underwriters has published requirements for repairs by fusion welding on boilers and pressure vessels.

The Boiler Code Committee of the A.S.M.E. has passed upon current requirements and has taken action calling attention to the fact that the revised rules would give safe results.

Copies may be obtained from the National Bureau of Casualty and Surety Underwriters, 1 Park Avenue, New York, N. Y.

SKYLINE OF CITY OF DALLAS

A.S.M.E. SEMI-ANNUAL MEETING

Dallas, Texas, June 15-20, 1936

THE North Texas Section of The American Society of Mechanical Engineers is preparing a hospitable welcome to the Society on the occasion of the 1936 Semi-Annual Meeting, to be held at Dallas, Texas, June 15–20, 1936.

For several months the local group, of which E. W. Burbank is chairman, has been cooperating with the Society's Committee on Meetings and Program in arranging the details of the meeting and in securing papers and speakers. As the meeting will take place during the early part of the Texas Centennial Exposition, which is being held at Dallas, Saturday, June 20, has been designated "Engineers' Day," at the Exposition.

TEXAS UNDER SIX FLAGS

One hundred years of progress and achievement as a republic and as one of the States of the Union will be celebrated in the 1936 Exposition, but the history of Texas covers four centuries.

Texas was discovered in 1519 by Alvarez de Pineda, a Spanish explorer, who claimed the territory for his king. A fellow Spaniard, Cabeza de Vaca, ship-wrecked on the coast in 1528, toiled across the vast trackless plains to California and became the first to explore the interior of Texas and the first transcontinental traveler. The cavalier LaSalle set up a colony at Fort St. Louis and struggled for three years to hold the land for France, but was unsuccessful.

In 1836 a handful of Texas frontiersmen won independence from Mexico by conquering Santa Anna, at San Jacinto. It is this event and the progress of subsequent years that the state-wide Centennial celebrations commemorate.

AKARD STREET, DALLAS, TEXAS

Six flags have flown over Texas soil—Spain, France, Mexico, the Republic of Texas, the Confederacy, and the United States. Texas was a republic for only nine years before voluntarily entering the Union as the twenty-ninth state; and the only state ever to have been internationally recognized as a sovereign power.

CENTENNIAL EXPOSITION

The Exposition climaxes numerous sectional celebrations, honoring men and events at the Alamo, in San Antonio, where Crockett, Bowie, Travis, and 180 other martyrs died rather than surrender; at San Jacinto, where General Sam Houston's meager band defeated Santa Anna's overwhelming force; at Gonzales, where the first shot of the Texas Revolution was fired; at Goliad, where Fannin and several hundred were massacred on Palm Sunday of 1836; at Galveston, where the pirate Jean Lafitte defied the world for seven years, and at many other historic spots.

TEXAS EXPOSITION FEATURES LIVESTOCK, AGRICULTURE, AND OIL

Whereas other world's fairs have featured science, the arts, or some other major phases of progress, the Texas Centennial Exposition stresses livestock, agriculture, and oil because these enterprises have been paramount in the building of the Lone Star economic empire. The largest agricultural and livestock exhibits ever assembled in one place will be housed in the five great buildings of the million-dollar Agrarian Way. Three major oil companies are erecting their own exhibit buildings at investments ranging from $50,000 to $120,000, while others have planned elaborate exhibits in the new Petroleum building.

INDUSTRIAL EXHIBITS

Science, manufacturing, and the fine arts are accorded proper attention, however, in other exhibit buildings. One of the major sections of the Exposition is the Cultural Center, erected by the City of Dallas, which includes museums of natural history, horticulture, domestic arts, fine arts, an aquarium and band shell, and open-air theater. Expenditures involving millions of dollars are being made by the leading industrial concerns of the nation who are participating in the Exposition, several of them for the first time in their histories.

Music holds a prominent place in the Exposition program with grand opera, famous orchestras and bands, musical comedy, radio productions, the national folk festival, and other events to be presented.

One of the outstanding features of the Exposition is the presentation, several times daily, of the Cavalcade of Texas, a dramatization of the 400 years' history of the Lone Star State. More than 300 actors, many of them direct descendants of the characters they portray, are in the cast. The stage is 300 ft wide and 175 ft deep, with water curtains dividing several different levels. A real stream flows before the footlights, with replicas of the boats of the early explorers floating in its waters. This is said to be one of the most ambitious stage presentations ever undertaken.

A.S.M.E. PROGRAM

The headquarters for the 1935 Semi-Annual Meeting will be the Hotel Adolphus, Dallas. Council meetings, committee meetings, registration, luncheons, and two popular lectures will be at the hotel. Most of the technical sessions will be held in the Power Building and the Telephone Building, both of which are within a block of the hotel.

Monday and Tuesday, June 15 and 16, are to be devoted to meetings of the Council. Tuesday noon members of the Council will be guests of the Dallas Technical Clubs at luncheon. The general business meeting of the Society is scheduled for Tuesday evening.

Technical sessions will be held on Wednesday and Thursday morning and afternoon, and on Friday morning. Friday afternoon will be devoted to inspection trips. On Saturday, which is Engineers' Day at the Exposition, A. A. Potter, past-president, A.S.M.E., and president, American Engineering Council, will deliver an address.

W. L. Batt, president, A.S.M.E., will speak at the luncheon on Wednesday, following which Hilding Tornebohm, of Goteborg, Sweden, will deliver the Calvin W. Rice Memorial Lecture. Mr. Tornebohm is chairman of the Committee on Fits and Tolerances of the International Standards Association, and chief engineer of the SKF Industries of Sweden. In 1928 he was awarded a gold medal by the Royal Engineering Academy for his work in connection with the establishment of the Swedish system of tolerances.

William Monroe White, of the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., will deliver an address entitled "The Why of Boulder Dam," on Wednesday evening. A general sociable get-together will be another feature of the Wednesday evening program. Other social events planned for the Dallas visitors are a dinner dance on Thursday evening at a country club, and a barbecue on Friday evening.

TELEPHONE BUILDING WHERE SOME TECHNICAL SESSIONS WILL BE HELD

"FORMAL DRESS" IN TEXAS

The Dallas Committee has written that full dress and formal dinner clothes are not necessary. Linen and other lightweight suits "are formal attire in the summer time in Dallas." Ten-gallon hats can be procured "on location."

CONTRASTING ARCHITECTURE IN MEXICO CITY

MT. POPOCATAPETL

MEETINGS BEFORE AND AFTER DALLAS

The week before the Dallas Meeting the A.S.M.E. Applied Mechanics Division will hold a national meeting at Pittsburgh, Pa., June 11 to 13, and the week after the Oil and Gas Power Division one at Ann Arbor, Mich., June 24 to 27. Notices of both of these meetings, which have been arranged so that members wishing to attend the Dallas Meeting as well may do so, will be found elsewhere in this issue (page 337).

SPECIAL TRANSPORTATION ARRANGEMENTS

For the comfort and convenience of the members attending the Dallas meeting, special railroad arrangements have been made coordinating the party in St. Louis, and from there to Dallas, Texas. Special railroad cars will be reserved on the Pennsylvania from eastern points; on the Wabash from Detroit; on the Alton from Chicago and vicinity. A special deluxe train leaves from the Union Station, St. Louis, Mo., on the Missouri-Kansas-Texas Railroad (Katy). Members from other mid-western points will have accommodations in special cars made up at Kansas City which will be attached to the special train from St. Louis.

The schedule from the various important centers is as follows:

(Eastern Schedule)

Lv. N. Y., Penn. R.R., 3:40 p.m., June 14
Lv. N. Phila., Penn. R.R., 5:08 p.m., June 14
Lv. Harrisburg, Penn. R.R., 7:14 p.m., June 14
Lv. Washington, D. C., Penn. R.R., 4:30 p.m., June 14
Lv. Baltimore, Penn. R.R., 5:19 p.m., June 14
Lv. Pittsburgh, Penn. R.R., 12:53 a.m., June 15
Ar. St. Louis, Penn. R.R., 1:00 p.m., June 15

(Mid-Western Schedule)

Lv. Detroit, Wabash R.R., 12:15 a.m., June 15
Ar. St. Louis, Wabash R.R., 7:30 a.m., June 15
Lv. Milwaukee, C.M. St. Paul, 9:05 p.m., June 14
Ar. Chicago, C.M. St. Paul, 11:05 p.m., June 14
Lv. Chicago, Alton, 11:59 p.m., June 14
Ar. St. Louis, Alton, 7:43 a.m., June 15

A.S.M.E. Special

Lv. St. Louis, M.K.T., 1:40 p.m., June 15
Ar. Dallas, M.K.T., 7:45 a.m., June 16
Lv. Kansas City, M.K.T., 3:00 p.m., June 15

To provide an opportunity to arrange for adequate pullman equipment, please notify A.S.M.E. headquarters what accommodations you will require.

Application has been made for reduced fare on the Certificate Plan. Members should purchase one-way tickets going, securing certificate from ticket agent which will entitle them to purchase return tickets at one third the regular fare returning. These certificates will have to be validated in Dallas before the return ticket can be purchased.

Because of Texas Centennial there is a possibility railroads will authorize round-trip fares at a rate that will be the same or less than the certificate-rate. As no definite information is available at present, inquiry should be made of your local ticket agent, or if you will ask A.S.M.E. headquarters to do so, you will be informed of the lowest rate available at the time from your home city.

MUSCLE SHOALS EN ROUTE TO DALLAS

Special arrangements have been made for those who would be interested to visit Muscle Shoals, Wheeler Dam, and Wilson Dam en route to the meeting in Dallas. For those arriving from eastern points on the Southern Railroad the train arrives at Sheffield at 2:30 a.m. Monday, June 15. If there are enough members interested to fill a sleeping car, the railroad will detach the car and members may remain in the pullman until 7:00 a.m. Starting from Sheffield at 7:00 a.m. a bus trip directly to Wheeler Dam will be made having breakfast at the Wheeler cafeteria. After breakfast an hour's inspection of the power house and dam itself will be made. The party will then motor back 14 miles to Wilson Dam for an inspection of the power house there. From Wilson Dam, A. M. Miller, member A.S.M.E. will pilot the party to the nitrate plant to see the new electric phosphate furnaces. The nitrate equipment itself is held in readiness for war munition needs but is not operated for agricultural nitrate production. This will bring the party back to Sheffield so that departure from there will be at 1:10 p.m. with arrival in Dallas, Texas, at 7:45 a.m. the following morning. As the arrangements for this trip depend to a large extent on the number of persons interested, those who would like to take it should so inform the A.S.M.E. headquarters.

AFTER THE DALLAS MEETING

Various plans for excursions after the Dallas meeting have been suggested.

LEISURELY TRANSPORTATION IN MEXICO

Members who so desire may go from Dallas to Houston, where parties can be arranged for trips to Port Arthur and the oil refineries, or to Galveston, or Freeport and Newgulf to visit the sulphur mines. Motorists, who do not drive on to Mexico City, may wish to visit Carlsbad Cavern.

NINE DAYS IN MEXICO

To provide a fitting climax to a profitable and entertaining week at the Semi-Annual meeting of the A.S.M.E. and the Texas Centennial at Dallas, Texas, the transportation committee has made arrangements for a nine-day all expense "Post-Convention Tour to Mexico." Many A.S.M.E. members feel that meeting of the Society in Texas is an opportunity to visit interesting and beautiful Mexico at a relatively small additional expense. Mexico is a land of contrasts; some of its manners, towns, and buildings, dating back to ancient Indian and medieval Spanish times, exist side by side with those of modern Mexico.

Leaving Dallas on Saturday evening June 20 the party will spend Sunday in San Antonio visiting the historic Alamo, the ancient missions, and Fort Sam Houston. Crossing the border that evening the train winds through Mexico's magnificent mountains, reaching at times altitudes over 7000 ft, finally arriving at Mexico City, the capital of Mexico. There are few cities in the world that are so ideally located and that exercise such a charm on the visitor. With the luxuriant verdure and wealth of flowers of the tropics, there is an almost perfect climate due to the city's high altitude—an ideal headquarters for the five days of travel about Mexico that the tour includes.

ENTRANCE TO SHRINE OF OUR LADY OF GUADALUPE

A day will be spent driving to Puebla and Cholula over scenic mountain roads with views of the active volcanoes of Popocatepetl and Ixtaccihuatl, through Indian Market, Santo Domingo Church, the House of El Alfenique, and the great Pyramids of Chohela. Another day, the party will drive to San Juan Tectihuacan, an archaeological city, the Temple of Quetzalcoatl, the Pyramids of the Sun and Moon, through Guadalupe, the site of the most sacred shrine in Mexico to Hidalgo, San Cristobal Ecatopec, and Acolman. On another day there will be an excursion which no trip to Mexico would be complete without—a visit to Cuernavaca, the "Atlantic City of Mexico," with a glance at the Palace of Cortez, the famous Cathedral, Borda Gardens, and thence to Xochimilco to revel in "Canaos" propelled by natives through beautiful floating gardens. Of native sports there may be seen Jai Ali, the fastest athletic game, a combination of tennis, handball, and lacrosse—and also the national pastime, the bullfight. Time will also be available to make a tour of the many quaint shops where thousands of interesting novelties will be found.

RURAL STREET SCENE

CONVENT OF LA MERCED

The all-expense rate from Dallas to Mexico City and return to Dallas on the basis of lower berth is $125 per person. This rate includes all charges for railroad, Pullman, sight-seeing, transfer, hotels (on basis of two persons to a room with bath), and all meals, except in Mexico City. Luncheons on sight-seeing trips out of Mexico City are provided. This rate includes the finest of all items available.

A complete pamphlet giving entire details is at present being prepared and will be sent upon request to the A.S.M.E. 29 West 39th St., New York, N. Y.

For those who care to drive to Mexico, a new highway has just been opened. This highway, known as the Mexico City-Nuevo Laredo route, was constructed at a cost of 54,000,000 pesos and was started in 1925. The drive from International Bridge to Mexico City should require less than four days and it is reported that more than 75 cars are passing over the new highway daily. Several A.S.M.E. members have already advised that they are planning to drive to Mexico City after the meeting and the A.S.M.E. headquarters staff will be pleased to assist any others who may be planning to drive.

As complete a program of events as is possible to give at this time appears on the following page.

Program of Events at Dallas

THE following program of technical sessions and other events at the Semi-Annual Meeting at Dallas is as complete as information received two months in advance of the date of the meeting makes possible. A complete program will be issued for distribution at Dallas, and further announcement will be found in the June issue.

Only a few manuscripts have been received for preprinting. It is expected that the May issue of the Transactions and the June issue of MECHANICAL ENGINEERING will contain as many papers recommended for publication as shall have been received in time. Other papers recommended for publication will appear in later issues of Transactions and MECHANICAL ENGINEERING. Discussion of all papers is invited.

MONDAY, JUNE 15

Committee Meetings

TUESDAY, JUNE 16

9:00 a.m.

Council Meeting

12:30 p.m. Luncheon of Council

As Guests of Dallas Technical Clubs

8 p.m.

Business Meeting

JUNE 17

WEDNESDAY MORNING

9:30 a.m. General

Agricultural Processing Industries and Rural Stability, by W. R. Woolrich
Discussions on Texas Industrial Development and Municipal Management

9:30 a.m. Railroad Locomotive

Equipment Problems in Handling Oil as a Locomotive Fuel, by Guy Bean
Discussions of Railroad Lubricants and Fuel Oil

9:30 a.m. Petroleum

Cementing Hot Oil Wells, by I. F. Bingham
Plunger Lift for Producing Deep Wells, by H. W. Fletcher
Discussion of New Methods in Oil-Field Production

12:30 p.m. Luncheon

Speaker: W. L. Batt, President, A.S.M.E.

WEDNESDAY AFTERNOON

2:00 p.m. Calvin Rice Memorial Lecture, by Hilding Tornebohm

3:15 p.m. Power

Cracked Residue Fuel Oils, by M. J. Hanlon
Analyzing Variable Load for Diesel and Steam Stations, by G. C. Boyer
Discussion of the Relative Merit of Heat Balance Vs. Water-Weighed Boiler Test

3:15 p.m. Transportation

Diesel Electric Locomotives for Switching and Transfer Service, by R. D. Krape
Mass Transportation for Cities, by J. C. Thirwall
Fuels for To-day's and To-morrow's Engines, by Earl Bartholomew and C. D. Howley

3:15 p.m.
Measurements and Regulation of Flow

Industrial Regulators, Their Theory and Application, by Ed S. Smith, Jr.
The Flow of Saturated and Compressed Liquids Through Orifices and Nozzles and a Series Orifice Control Element, by Milton C. Stuart
Discussion of Fluid Meters Research

3:15 p.m. Machine Shop

U. S. Army Airplane Maintenance System, by John H. Howard
The Use of the X-ray Testing of Welded Vessels, by H. R. Isenburger
The Spraying of Molten Metal, by I. E. Kunkler

WEDNESDAY EVENING

Evening Lecture

The Why of Boulder Dam, by William Munroe White

JUNE 18

THURSDAY MORNING

9:30 a.m. Petroleum

Heat Transfer and Pressure Drop in Shell and Tube Liquid to Liquid Heat Exchangers, by B. E. Short
Discussions on A.S.M.E.-A.P.I. Unfired Pressure Vessel Code and Corrosion of Pipe Lines

9:30 a.m. Education and Training

Vocational Training in the Southwest, by A. W. Breeland
Discussions on National Training Program and Air Corps Training

9:30 a.m. Process and Power

Power and Heat Problems in the Sulphur Mining Industry, by C. L. Orr
Chlorination of Circulating Water and Algae Control, by Robert R. Crowdus
Operating Experiences With Automatic Combustion Control When Burning Gas and Acid Sludges, by Thomas E. Crossan and A. J. Matherne, Jr.

12:30 p.m. Luncheon Meeting

THURSDAY AFTERNOON

2:00 p.m. Petroleum

Economic Operating Cost Analysis of Several Totally Electrified Pipe Lines, by Winfred H. Stueve
Discussions on Steam Drilling Equipment and on Wire-Line Coring

2:00 p.m. Process and Power

Sensible and Latent Heat Control for Air Conditioning, by F. W. Rabe, Jr.
Compressibility Determination Without Volume Measurements, by E. S. Burnett

2:00 p.m. General

Production of Helium, by C. W. Seibel
The Manufacture of Carbon Black, by Hilding Hanson
Discussion on Improvement in Cast Iron Pipe

THURSDAY EVENING

Evening Dinner Dance at Country Club

JUNE 19

FRIDAY MORNING

9:30 a.m. Petroleum and Oil and Gas

Design of Diesel Electric Oil Well Drilling Units, by D. M. McCargar and O. A. Hass
Discussions on High Speed Gas and Diesel Engines for Pumping and Drilling

9:30 a.m. Fuels and Power

Operating Experience With Pulverized Texas Lignite in a Large Central Station, by Norman G. Hardy
Design and Operating Features of the 1450-Lb Deep-Water Steam and Electric Station, by H. G. Hiebeler
Utilization of Natural Gas Fuel for Central Stations, by Elmer F. Schmidt

9:30 a.m. Process

Mechanization of the New Mexico Potash Mines, by H. I. Smith and R. V. Ageton
Sulphur Mining, by G. C. McMillen
The Development of the Air-Float Method of Gravity Separation, by R. R. Slaymaker

9:30 a.m. Hydraulics

A Modern Rice Irrigation System, by W. B. Gregory
Irrigation Pump Equipment and Practice, by B. S. Nelson

12:30 p.m. Luncheon

FRIDAY AFTERNOON

2:30 p.m. Trips

FRIDAY EVENING

Evening Barbecue

SATURDAY, JUNE 20

Engineers' Day at Centennial Exposition

Speaker: Dean A. A. Potter, President, American Engineering Council

Graphic Arts Meeting at Washington, May 11–13

THE program of the Graphic Arts Technical Conference, to be held in Washington, D. C., May 11–13, has been arranged by the Graphic Arts Research Bureau and the Graphic Arts Division of the A.S.M.E. The meeting will consist of two days of technical sessions at the Wardman Park Hotel, with Wednesday, May 13, open for inspection trips to the Government Printing Office and other Government bureaus.

The program opens on Monday morning, May 11, with a session on the relation of paper to printing. On Monday afternoon there will be a session on printing metals. A dinner will be held in the evening at the hotel with entertainment by employees of the Government Printing Office. There will also be an address by the famous Arctic explorer, Dr. Vilhjalmur Stefansson, who has promised an amusing talk on the "Need for the Standardization of Error."

On Tuesday morning printing processes and their evaluation will be discussed, and in the afternoon management and tone reproduction.

A registration fee of $3 will include a ticket to the Monday evening dinner.

A detailed program follows:

MONDAY, MAY 11

8:30 a.m. Registration

9:00 a.m. Paper Symposium

Paper and Its Application to Printing, by Arthur S. Allen

Quick-Drying Inks, by E. L. Duhring

2:00 p.m. Metal Symposium

Sheet Zinc for Photoengraving, by Wm. H. Finkeldey

Impression Lead for Electrotype Molding, by Howard Baker

Photoengravers' Zinc, by Ernest W. Spencer

Sheet Brass for Photoengraving, by B. H. McGar

Sheet Copper for Photoengraving, by R. W. Myers

The Constitution and Properties of Type Metals, by Samuel Epstein

6:30 p.m. Informal Dinner

Toastmasters: A. C. Jewett and A. E. Giegengack

Special Entertainment by Government Printing Office Employees

Speaker: Dr. Vilhjalmur Stefansson, Arctic Explorer

TUESDAY, MAY 12

9:00 a.m. Evaluation of Processes Symposium

This symposium will discuss the application and evaluation of printing processes, organized by T. E. Dalton. The merits, scope, and limitations of these processes will be analyzed—relief or letter press, planography or lithography, intaglio or gravure. The object is to guide the printer in expanding his facilities and the buyer in selecting the best process to fit the job.

2:00 p.m. General

An Analysis of General and Specialized Production, by C. O. Wellington

Tone Reproduction in Relief Printing, by Alexander Murray

Nitric-Acid Etching of Zinc in Photoengraving, by E. R. Boller

Heat-Treated Electrotypes, by R. H. Schwarz and J. H. Winkler

WEDNESDAY, MAY 13

Open for visits to Government Printing Office and Bureau of Engraving

Applied Mechanics Meeting at Pittsburgh, June 11–13

THE Applied Mechanics Division of the A.S.M.E. will hold its National Meeting in Pittsburgh, Pa., on June 11, 12, and 13 under the auspices of the Society and the sponsorship of the Pittsburgh Section.

Four technical sessions are being planned with several inspection trips through research laboratories in the Pittsburgh district. The technical program will consist of a vibration session which is being organized by Prof. F. M. Lewis of Webb Institute; a session on creep and plasticity being arranged by Dr. A. Nadai, of the Westinghouse Electric & Manufacturing Co.; and a session on elasticity being planned by Prof. S. Timoshenko of the University of Michigan. The final session will be of general technical interest and organized by Prof. E. O. Waters of Yale University, who is chairman of the Applied Mechanics Division.

The Division has appointed R. E. Peterson and Max Frocht as its representatives to work out local arrangements with the Pittsburgh Section.

Oil and Gas Power Meeting at Ann Arbor, June 24–27

THE ninth national Oil and Gas Power Meeting, under the auspices of the A.S.M.E., will be held at the University of Michigan, Ann Arbor, Mich., from June 24 to 27.

The technical program is now being planned by the A.S.M.E. Oil and Gas Power Division to begin on Wednesday, June 24, with an afternoon session at which Diesel training, Diesel legislation, and gas-engine developments will be discussed. On Thursday morning there will be a design session covering bearings and speed-regulation problems. Thursday afternoon will be devoted to an operation session with papers on Diesel lubrication and maintenance, and in the evening there will be a symposium on high-speed engine development. A research session discussing fuel oil, metallurgy, and high-speed engine lubrication will be held on Friday morning, with Saturday morning given over to transportation, with discussion on Diesel busses and locomotives.

The A.S.M.E. Detroit Section is the local sponsor of the meeting in cooperation with the University of Michigan. An interesting program of inspection trips, picnics, and evening entertainment is being planned. Prof. C. W. Good is chairman of the local arrangements.

As part of the meeting there will be the usual exhibit of Diesel-engine parts and accessories. This will be held in the lobby of the Eastern Engineering Building which will also be the headquarters for registration and technical sessions.

Third World Power Conference at Washington, D. C., Sept. 7–12, 1936

THE Third World Power Conference will be held in Washington, D. C., Sept. 7–12, 1936, in connection with the Second Congress of the International Commission on Large Dams. Among the institutional members of the conference is The American Society of Mechanical Engineers. Copies of a brochure describing the Conference and outlining the scope of the national papers solicited for presentation may be obtained from O. C. Merrill, Director, Third World Power Conference, Interior Building, Washington, D. C.

GENERAL PROGRAM

A list of the National papers requested for the conference, which will convey an idea of the scope and character of the subjects to be discussed, is as follows:

Section 1 Physical and Statistical Basis of the National Power Economy; Technical, Economic, and Social Trends: Power Resources, Development and Utilization; Significant Trends in the Development and Utilization of Power Resources; and Collection, Compilation, and Publication of Statistics with Particular Reference to International Use.

Section 2 Organization of the Fuel Industries: Organization of the Production, Processing, and Distribution of Coal and Coal Products; Organization of the Production, Refining, and Distribution of Petroleum and Petroleum Products; and Organization of the Production, Transportation, and Distribution of Natural and Manufactured Gas.

Section 3 Organization and Regulation of Electric and Gas Utilities: Organization of Private Electric and Gas Utilites; Public Regulation of Private Electric and Gas Utilities; and Organization, Financing, and Operating of Publicly Owned Electric and Gas Utilities.

Section 4 National and Regional Planning for Most Efficient Utilization of Natural Resources: National and Regional Planning and Their Relation to the Conservation of Natural Resources; Conservation of Coal Resources; and Conservation of Petroleum and Natural Gas.

Section 5 Special Problems in Regional Planning: Planned Utilization of Water Resources; Utilization of Small Water Powers; and Regional Integration of Electric and of Gas-Utility Facilities.

Section 6 Rationalization of Distribution: Rationalization of Distribution of Electric Energy and of Gas; and Rural Electrification.

Section 7 National Policies: National Power and Resources Policies.

OFFICERS OF THE CONFERENCE

The World Power Conference is a federation of national committees and representatives of some 50 countries organized in 1924 upon the initiative of the late D. N. Dunlop, of Great Britain. The officers of the Third Conference are: Honorary president, Franklin D. Roosevelt, President of the United States of America; honorary vice-president, Harold L. Ickes, Secretary of the Interior; chairman, William F. Durand, past-president, A.S.M.E.; and director, O. C. Merrill, consulting engineer.

The officers of the American Committee are: chairman, Harold L. Ickes; vice-chairman, William F. Durand; chairman executive committee, Morris L. Cooke, Administrator, Rural Electrification Administration, member A.S.M.E.; and executive secretary, Joel David Wolfsohn, executive secretary, National Power Policy Committee.

The officers of the Second Congress International Commission on Large Dams are: president, G. Mercier, France, Ingénieur en Chef des Ponts et Chaussées; A. Genthial, France, Ingénieur des Ponts et Chaussées; and organizing director, United States, O. C. Merrill.

William L. Batt, president, The American Society of Mechanical Engineers, has been designated official representative of the Society. Several A.S.M.E. professional divisions are cooperating.

A.E.C. News From Washington

IT IS "open season" in Washington for speculation regarding future relief, work relief, and emergency spending programs. Buchanan, Glass, and the President are generally conceded to desire economy sincerely and are credited with the intention of staying within budget estimates, but they allow Congress to compromise. Members of Congress talk economy and tremble over the thoughts of inflation and heavy increases in taxes, but yield to reelection temptations and the use of borrowed money.

Just when Congress was gaining strength to resist persuasion from the heads of the emergency agencies and callous political subdivisions for the continuation of huge appropriations for loose spending, almost unprecedented storms and floods struck enough of the eastern states to weaken or eliminate the resistance. Some of the more threatening investigations of the activities of emergency agencies are about to be abandoned, and hearings involving more billions are crowding economy ideas and new schemes of taxation for attention.

With support of actual unexpected needs arising in the newly stricken areas and the emotional reactions from other parts of the country, it begins to look as if the Public Works Administration might get $750,000,000 to complete its commitments and $1,500,000,000 might be appropriated for the continuation of other emergency activities.

Congress has not confined its generosity to relief and emergency appropriations. It is weakening under pressure to increase the appropriations for the regular departments, and extras are accumulating in pending deficiency measures. So, despite economic improvement and good intentions, expenses are rising faster than revenues and the outlook for the next fiscal year is as much as two billion dollars out of balance.

We continue to see evidences of a behind-the-scenes trend toward balancing the budget but its realization now looks to be several years away. Campaign-year commitments are likely to carry federal government financing of spending well into 1937 and lead to further inflation of the credit base. Conditions are improving rapidly enough, however, to prevent any collapse of government credit within the visible future.

PUBLIC WORKS ADMINISTRATION

Setiment "on the Hill" is decidedly favorable to the public-works type of spending with a policy similar to the present grant and 4 per cent loan basis, but members of Congress do not support it exclusively because it has not been made applicable to the smaller communities and because of personal differences with Secretary Ickes. They want to discourage undertakings like the Florida Canal and Quoddy but will vote to continue to completion the average project already under construction.

WORKS PROGRESS ADMINISTRATION

Hopkins cannot hope to escape more charges of inefficiency, waste, and the indirect use of relief funds for political purposes, but the "breaks" of distress are with him and criticism only emphasizes the fact that he has attained the goal for the distribution of funds on a work-relief basis where others have failed to provide the expected employment for the heads of relief families. In many instances he admits mistakes as he proves that he got "the spending job" done. He is still strong with the Administration.

PROCUREMENT DIVISION

No changes in policies have been announced by the Procurement Division of the Treasury. They have committed themselves to the limit of their appropriations and are furloughing designing engineers and architects until they know what funds are to be made available. Their program is comparatively free of criticism here and observers agree that it is likely to be continued.

RECLAMATION

A large portion of the new appropriations is likely to go to reclamation under pressure from the West and western members of Congress. Little criticism of reclamation work is heard in Washington, and where the projects mesh in with soil erosion, conservation, and land utilization the comment is favorable. The momentum from the able leadership of Dr. Mead carries its activities on in expectation that another strong engineer executive will continue the constructive policies.

GOVERNMENT REORGANIZATION

The sound economical purposes of the current agitation for the reorganization and consolidation of departments and agencies of the federal government are confused with political strategy. The studies are scheduled to be made by the Brookings Institution under the direction of Senator Byrd's committee headed by Dr. Louis Brownlow of Chicago, but the leaders of the movement admit its lack of organization and are admittedly doubtful about its success.

The Council has placed the recommendations of its committees and its files of valuable factual information regarding the increases in efficiency and economies that might result from reorganization and consolidation of kindred government agencies at the disposal of Senator Byrd's committee and the Brookings Institution. We have discussed the situation with those in charge and made them understand that the Council is sympathetic and anxious to be of service. So much of what could be done, however, depends upon political pressure and the organization of the work of the committee is proceeding so haltingly that no action is expected until after the election.

COUNCIL FOR INDUSTRIAL COOPERATION

The staff has been in close contact with Maj. George L. Berry's Council for Industrial Cooperation. It was supposed to have been organized at the request of the President to develop a closer understanding between government, labor, and industry, and an acceptable application of some of the better phases of the "late" National Recovery Administration. It was believed by some to be an unbiased group of committees, with a small administrative organization, until Berry announced the formation of a "nonpartisan labor league" to work for the reelection of Roosevelt. That announcement followed an executive order creating two new units out of the NRA skeleton—the Committee of Industrial Analysis and a Council of Industrial Progress. Both appear to be aimed at new legislation governing wages and hours in the next session of Congress.

On its face this seems like a strange conclusion to the efforts of several committees of serious-minded business men, one of which was invited to determine the effects of government spending and competition upon private enterprise. It was "officially rumored" in that connection that the President was anxious to have practical recommendations for at least a partial elimination of government competition. In any event, $40,000 of the emergency relief appropriation of 1935 has been reserved for the continuation of Coordinator Berry's activities.

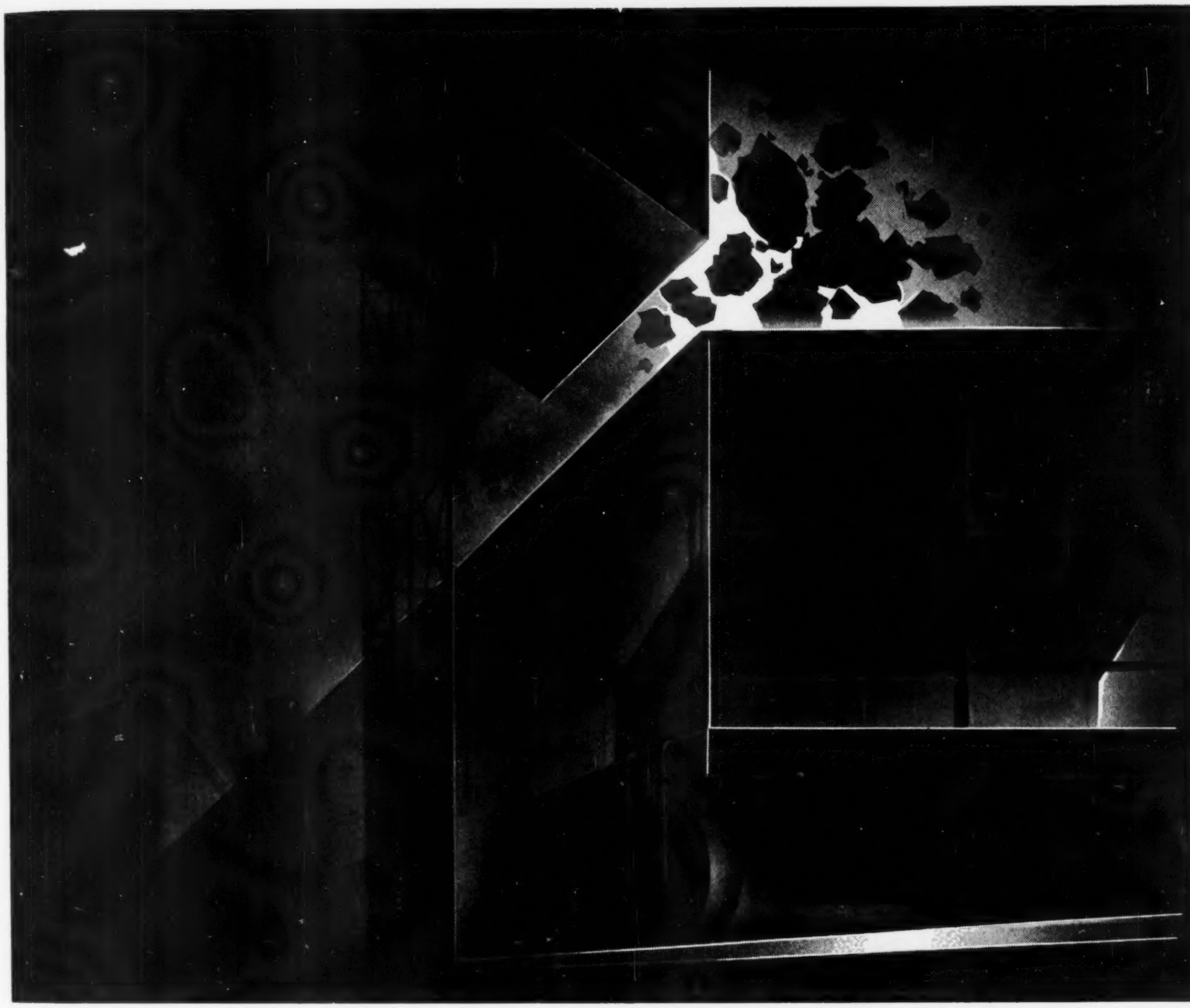
NEW YORK ELECTRICAL SOCIETY

We are happy to announce receipt of an application for membership from the New York Electrical Society which was founded in 1881. The Society has more than six hundred members and we are sure that their coming in the spirit of unity will add to the Council's prestige.

A.S.M.E. STUDENTS' CONFERENCE

Some 150 mechanical engineering students

(*Continued on p. 340*)



Where weight and expense are partners

It is estimated that reducing the empty weight of a railroad car one ton means an annual operating saving of $17.97 per car. The high weight-strength ratio of the "Moly" steels used in car construction permits an average reduction of 4.5 tons per car. Result: $89.85 annual savings per car.

That is vitally important itself. But — Moly steels are also exceptionally well fitted to withstand the terrific manhandling, abuse and corrosion that is the ordinary lot of rolling stock. Lower operating costs plus longer service permit greater profits.

Your steel problems may be—probably are—"different." They may involve creep strength or fatigue strength, or temper brittleness, or just plain fabricating economy. Whatever they are, it will pay you to investigate Molybdenum.

The wide experience of the engineers in our experimental laboratories is at your disposal. Our technical book, "Molybdenum," and our news-sheet, "The Moly Matrix," will gladly be sent you on request. Climax Molybdenum Company, 500 Fifth Avenue, New York City.

Visit the Climax exhibit in booth 116 at the Foundry and Allied Industries Exposition in Detroit, May 4-9.

CUTS COSTS MOLY Mo-lyb-den-um CREATES SALES

in engineering colleges are holding a student's conference in Washington on April 27 and 28, 1936. Council is helping arrange their visit to the White House and welcomes the opportunity to give young engineers first-hand information about the functions of National Government and the Capital of the United States.

A.E.C. COMMITTEE ACTIVITIES

Almost every engineer invited to serve on the Council's committees has accepted and some committees are becoming active. The new program will be formally inaugurated by the executive committee at its meeting in Washington during the last week in April and presented as cases for consideration to the several committees. That will include the new State Public Affairs Contact Committee, which is being created to stimulate an increasing interest in public affairs through the promotion and support of state and local public-affairs committees and to serve as a clearing house, in both directions, for sound ideas and factual information along engineering and economic lines.

Max Jakob Lectures

ON THURSDAY, April 2, Dr. Max Jakob, of Berlin, Germany, well known to engineers of this country for his work on the properties of steam and heat transfer, was guest of honor at a dinner at the Engineers' Club, New York, N. Y.

Geo. A. Orrok presided, and brief addresses of greeting and welcome, to which Dr. Jakob responded, were delivered by C. E. Davies, Secretary, A.S.M.E., for The American Society of Mechanical Engineers, Robert Ridgway, for the American Society of Civil Engineers, George L. Knight, for the American Institute of Electrical Engineers, and George B. Pegram, for the physicists represented by the American Physical Society and the American Institute of Physics.

SCHEDULE OF DR. JAKOB'S LECTURES

George F. Bateman, Dean of Engineering, Cooper Union, announced that the purpose of Dr. Jakob's visit to this country was to deliver lectures to educational and research institutions. The first lecture had been delivered that day at Pratt Institute. The schedule for the remaining lectures is as follows: April 3, Stevens Institute of Technology; April 6, Princeton University; April 7 to 15, Massachusetts Institute of Technology, and Harvard University (six lectures); April 16 and 17, General Electric Company at Schenectady (two lectures and one general meeting); April 20, Polytechnic Institute of Brooklyn; April 21, Philadelphia—A.S.M.E. Local Section; April 22, Cooper Union, morning, and A.S.M.E. Metropolitan Section, evening; April 23, Newark College of engineering, morning, and A.S.M.E. Metropolitan Section, evening; April 24, Columbia University, morning, and A.S.M.E. Metropolitan Section, evening; April 27 and 28, University of Illinois; and May 1 to 8, University of California.

Franklin Medals Awarded Jewett and Kettering

THE Franklin Institute of the State of Pennsylvania, announces that the Franklin Medal this year will be awarded to Frank Baldwin Jewett, Ph.D., D.Sc., D.Eng., LL.D., vice-president, American Telephone and Telegraph Co., president and director, Bell Telephone Laboratories, Inc., New York, N. Y.; and to Charles Franklin Kettering (Mem. A.S.M.E.), Hon.D.Eng., D.Sc., vice-president and director, General Motors Corporation, general director, General Motors Research Laboratories, Detroit, Mich.

The Franklin Medal is awarded annually from the Franklin Medal Fund, founded January 1, 1914, by Samuel Insull, Esq., "to those workers in physical science or technology, without regard to country, whose efforts, in the opinion of the Institute, acting through its Committee on Science and the Arts, have done most to advance a knowledge of physical science or its applications."

Dr. Jewett will receive the medal "in recognition of his many important contributions to the art of telephony, which have made conversation possible not only from coast to coast, but from this country to the other side of the world—contributions of which some were made by him alone, and some by him in collaboration with other workers in the great laboratory of research which he organized and which he has directed with such signal success."

Dr. Kettering will receive the medal "in recognition of his significant and timely contributions to the science of automotive engineering—a science out of which has grown the greatest industry in this country, the manufactured product of which has, in only a quarter of a century, changed the face of the civilized world."

D. L. Fiske to Represent A.S.R.E. at International Congress

AT THE Seventh International Congress of Refrigeration, which will be held the week of June 16, 1936, at The Hague, Holland, the American Society of Refrigerating Engineers will be officially represented by its secretary, David L. Fiske, who plans to make a tour touching several countries besides Holland. His itinerary will include stops at centers of refrigerating interest on the continent, and in England.

On May 24 and 25, Mr. Fiske plans to attend the annual meeting of the German Refrigeration Association at the invitation of Dr. Rudolph Plank, distinguished teacher and engineer, chancellor of the University of Karlsruhe, where the famous refrigeration institute and laboratory are located. Mr. Fiske will later proceed to Paris where a number of members of the society are located, as well as the headquarters of the International Institute, and thence to Copenhagen, where he will address the Danish refrigerating organization.

Annual Tables of Constants

IN THE list of Books Received in this issue will be found a note on Part 2 of Volume 10 of the Annual Tables of Constants and Numerical Data. Part 1 was noted in the November, 1935, issue of MECHANICAL ENGINEERING.

Copies of "Engineering and Metallurgy," extracted from Volume 10 under the editorship of L. Descroix, of *Revue de Metallurgie*, will shortly be available and may be secured by members of the A.S.M.E. at half price, or $4 a copy. Members of the Society who purchase this extract may also obtain copies of the extract on "Engineering and Metallurgy" from Volumes 8 and 9 at the same price, and similar material from Volumes 6 and 7, as long as available, without charge. The texts of these reprints are in both English and French, as are also the complete volumes.

Orders should be placed with the A.S.M.E. Publications-Sales Department before June 30, 1936.

New York State Holds Engineers' Licensing Examinations

A TOTAL of 500 candidates took the January, 1936, written examinations under the Engineers' Registration Law in New York State. Of these, 89 were conditioned, 25 failed, and 386 passed.

At the February meeting of the Board of Examiners, 169 applications were considered. Of these, 12 were held for interview, 53 were scheduled for written examination, 47 were rejected, and 57 were approved for license.

J. H. Englebrecht Takes Over A.S.M.E. Mid-Continent Office

SINCE the first of March, The American Society of Mechanical Engineers has been represented in the Mid-Continent area by J. H. Englebrecht, who also serves as secretary of the Tulsa Engineers' Club. Mr. Englebrecht's office is at present in the Midco Building, Tulsa, Okla.

Chicago Section to Hold Dinner Dance

THE Chicago Section of the A.S.M.E. will hold a dinner dance in connection with the National Defense meeting on May 15, in the Tower Room of the Stevens Hotel.

Dinner will be served at 7:15 after which a short business meeting is scheduled, to elect local section officers for the next year.

The principal speakers of the evening will be Admiral John Downes, Commandant of the 9th Naval District whose subject will be "Recent Advances in Our Naval Defense," and William L. Batt, President of The American Society of Mechanical Engineers.

Arrangements are being made to have a high

(*Continued on p. 342*)

ranking army officer as toastmaster for the dinner.

There will be dancing from 10:00 p.m. until 1:00 a.m. Those who do not care to dance will be given the opportunity to make up tables of bridge or pinochle and compete for table prizes.

Any members of the A.S.M.E. and their guests from other Sections are invited to attend this important meeting if they have occasion to be in Chicago at the time. Tickets are $2.50 per person. Dress may be either army uniforms, dinner jackets, or business suits.

Coming Meetings of A.S.M.E. Local Sections

Akron-Canton: May 21. Inspection trip through plant of the Alliance Machine Co., at Alliance Ohio. Meeting at 6:30 p.m. Subjects: An Illustrated lecture on Car Dumper Installation, by W. D. Keller, design engineer, Alliance Machine Co., Alliance, Ohio; 270-Ton Gantry Crane built for Wheeler Dam, by R. Bowerman, engineer of the Alliance Machine Co.

Chicago: May 15. Annual meeting and election of Section officers. Subject: National Defense.

Detroit: May 4. Afternoon Inspection tour through the Ford Motor Company, River Rouge Plant, followed by a buffet supper in honor of our student branch members and guests at the Dearborn Inn. Between the tour and supper there will be a period available for those who wish to visit either the Ford Museum at Dearborn or Greenfield Village. After supper an evening program will be given in the ballroom of the Dearborn Inn. President Batt will be the principal speaker and will give an address on "Unity Begins at Home." Representatives from three student branches will be called upon for two-minute talks.

Knoxville: May 12–13. Kingsport Inn, Kingsport, Tenn. Subject: Industrial Power, by E. W. O'Brien, managing director, *Southern Power Journal* and a Vice-President of the A.S.M.E.; Research Opportunities for the Small Industry, by Ford L. Wilkinson, Jr., associate professor, in mechanical engineering, University of Tennessee; Development of New Products, by a representative of the Tennessee Eastman Corporation, Kingsport. At the dinner E. W. Palmer, President of the Kingsport Press, will present an address on The Problems of Southern Industry. On the morning of May 13 the following subjects will be discussed: Industrial-Incentive Wage System, by Mr. Triebe of the Kingsport Press; Transportation, by J. H. Alldredge, Tennessee Valley Authority.

Metropolitan: May 8. National Defense Junior Group. Subject: Aviation With Relation to Our National Defense, by Col. Frank P. Lahm, Air Officer, Second Corps Area, United States Army.

Nebraska: May 25. Meeting and Dinner at 6:30 p.m. at the Miller and Paine Department Store, Lincoln, Neb. Subject: Air Conditioning, by A. G. Hillen, sales engineer, Chicago Office, Carrier Corporation. An inspection of the new air-conditioning system in the store will follow the address of the evening.

Philadelphia: May 26. Afternoon and evening outing which will include golf, tennis, and other sports, dinner in the evening, and speakers on non-technical subjects.

Youngstown: May 13. Republic Rubber Company Club House at 8:00 p.m. Subject: Unity Begins at Home, by William L. Batt, President of the A.S.M.E.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after May 25, 1936, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member having comments or objections should write to the secretary of the A.S.M.E. at once.

New Applications

Bouvier, Geo. A., Chicago, Ill.
Brown, Harold D., Chicago, Ill.
Capuano, Alfred J., New York City, N. Y.
Cave, John R., Jr., Bayside, L. I., N. Y.
Chase, Julian Dwight, Providence, R. I.
Christie, Robt. W., Jersey City, N. J.
Christmann, J. L., Passaic, N. J.
Courtenay, M. H., Atlanta, Ga.
Covey, Kenneth S., Northport, L. I., N. Y.
Cucullu, Lionel J., New Orleans, La.
Derry, Gardner C., Sharon, Mass.
Dohrmann, Henry Chas., Warren, Pa.
Frautschi, Carl, Toledo, Ohio
Fretter, N. F., Cleveland Heights, Ohio
Gilbert, Lowell B., Wesleyville, Pa. (Rt)
Ginochio, Chas. E., Sacramento, Calif.
Hartman, L. G., Seattle, Wash.
Hayes, M. F., Middletown, Ohio
Henry, Scott L., Grand Forks, N. D.
Hubbard, Karl H., Rochester, N. Y.
Johnson, Ralph Blake, Hawaii, T. H.
Krider, Roderic M., Oakland, Calif.
Larson, G. W., Kansas City, Mo.
Lloyd, John A., Wilkes-Barre, Pa.
Lofgren, Kenneth E., New York, N. Y.
McIntosh, Wm. J., Seattle, Wash. (Rt)
Miller, Carl E., Alexandria, Va.
Muir, R. C., Schenectady, N. Y.
Murphy, Robt. E., Elmhurst, L. I., N. Y.
Norling, Bert S., Neenah, Wis.
Olt, Richard G., Dayton, Ohio
O'Neil, Chas. H., Brooklyn, N. Y.
Patterson, J. B., Chicago, Ill.
Porter, R. Clay, Lexington, Ky.
Rolle, Carl, New York, N. Y.
Schanze, Carl R., Philadelphia, Pa.
Smith, W. Manning, Port Richmond, S. I., N. Y.
Stepan, Theo. E., Tucumcari, New Mex. (Rt)
Stewart, Warren D., Wollaston, Mass.
Thompson, S. John, Shropshire, England (Rt)
Truman, Frederick, Toronto, Ont., Canada
Viscusi, Wm. E., Bridgeport, Conn.
Vogelsang, L. O., San Antonio, Tex.
Wallene, Frank O., Cleveland, Ohio
Weber, W. C., Corning, N. Y.
Willson, D. S., Conshohocken, Pa.
Woodruff, H. S., Larchmont, N. Y.
Wuest, Louis L., Brooklyn, N. Y. (Rt & T.)

Change of Grading

Transfers from Member

Fast, Gustave, Annapolis, Md.
Keeth, Grover, Wausau, Wis.
Stanton, A. Lennox, St. Austell, Cornwall, England
Wharton, J. R., Columbia, Mo.

Transfers from Junior

Crowdus, Robt. R., Dallas, Tex.
Elmer, Lloyd A., New York, N. Y.
Hooper, Leslie J., Holden, Mass.
Onderdonk, Paul T., Brooklyn, N. Y.
Schoerke, D. A., Petrolia, Pa.
Tinker, Townsend, Buffalo, N. Y.
Zerban, Prof. Alexander H., State College, Pa.

Necrology

THE following deaths of members have recently been reported to the Office of the Society:

Allen, Charles B., February 13, 1936
Anderson, Gus R., March 10, 1936
Anderson, St. George M., February 24, 1936
Belcher, Paul W., February 28, 1936
DuPuy, Thomas F., March 21, 1936
Hulse, Edward Pierce, April 3, 1936
Jackson, Henry W., March 19, 1936
Kenner, Ernest R., March 23, 1936
Nevill, David J., February 7, 1936
Porter, Minott E., February 26, 1936
Rathmell, John M., December 13, 1935
von Oswald, Wilhelm, March 22, 1936

A.S.M.E. Transactions for April, 1936

THE April, 1936, issue of the Transactions of the A.S.M.E., contains the following papers:

Pressure Losses in Rectangular Elbows (AER-58-2), by R. D. Madison and J. R. Parker
The Direct Firing of Pulverized Anthracite Silt (FSP-58-3), by Martin Frisch
Heat Transmission in Steel-Reheating Furnaces (PRO-58-1), by J. E. Eberhardt and H. C. Hottel
Measurement of Gas Temperatures in an Internal-Combustion Engine (PRO-58-2), by A. E. Hershey
Tests of Radiation From Luminous Flames (PRO-58-3), by W. Trinks and J. D. Keller
Effect of Concentrated Sodium Hydroxide on Boiler Steel Under Tension (RP-58-7), by A. S. Perry
Estimation of Dissolved Solids in Boiler Water by Density Readings (RP-58-8), by J. K. Rummel and J. A. Holmes
Effect of Solutions on the Endurance of Low-Carbon Steel Under Repeated Torsion at 482 F (250 C), (RP-58-9), by W. C. Schroeder and E. P. Partridge.

DISCUSSION

On previously published papers by S. L. Kerr; J. L. Carruthers; B. S. Cain; H. C. Hottel and V. C. Smith; B. F. Langer and J. P. Shamberger; L. S. Marks and T. Flint; C. E. Peck and M. D. Ross; A. Williams; L. S. Marks; and G. A. Hawkins, H. L. Solberg, and A. A. Potter.